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THE OCTOBER SCIENTIFIC MONTHLY

EDITED BY J. McKEEN CATTELL

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NEW BOOKS OF SCIENTIFIC INTEREST

The Vegetable Industry. HENRY ALBERT JONES and SAMUEL LEONARD EMSWELLER. viii + 431 pp. Illustrated. $2.25. McGraw-Hill Book Company.

This high-school text-book deals mainly with the production phases of the vegetable industry. The method of classifying the crops has been based upon botanical relationships. The authors are members of the College of Agriculture at the University of California.

Social Process and Human Progress. CLARENCE MARSH CASE. 336 pp. $2.50. Harcourt, Brace and Company.

This book is an analytical study of the idea of progress and its relationship to consecutive human activity. "Social progress" is defined as "utilization, equalization and appreciation." The author is professor of sociology at the University of Southern California.

Culture and Education in America. HAROLD RUGG. xii + 404 pp. $2.75. Harcourt, Brace and Company.

A tentative outline of the chief concepts of American culture and of needed steps in educational reconstruction. The author considers his contribution as "essentially a preface to a theory of life and education."

The First Two Years—A Study of Twenty-Five Babies. Vol. I. Postural and Locomotor Development. MARY M. SHIRLEY. xv + 227 pp. Illustrated. $2.00. The University of Minnesota Press.

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Mind and Matter. G. F. STOUT. xiv + 325 pp. $3.75. The Macmillan Company.

The author's purpose is "an examination of certain aspects of ordinary experience—those involved in the knowledge of the physical world, of the self and of minds other than our own." This is the first of two volumes based on the Gifford Lectures delivered at the University of Edinburgh.

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Mexico is considered in the past, present and future. The author compares two economic systems —handicraft and machine—and reflects upon the futures of the two systems, suggesting possible good reciprocal influences. The book has been illustrated by Diego Rivera.

To the Ends of the World and Back. J. WALKER MCSPADDEN. xv + 362 pp. Illustrated. $3.00. Thomas Y. Crowell Company.

Stories of fifteen field men connected with the American Museum of Natural History. The author has been in personal contact with these modern explorers who make possible the exhibits in the museum. The first chapter is based upon an interview with Henry Fairfield Osborn.

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A Survey of the Medical Facilities of the City of Philadelphia. NATHAN SINAI and ALDEN B. MILLS. 298 pp. $1.50. (Paper cover.) The University of Chicago Press.

This report, in which are embodied material regarding private practitioners and a digest of the Philadelphia hospital and health survey, gives a picture of medical service in Philadelphia.

Economics for Engineers. EDISON L. BOWERS and R. HENRY ROWNTREE. viii + 490 pp. Illustrated. $4.00. McGraw-Hill Book Company.

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Steps in the Dark. MILTON MAYER and JOHN HOWE. 227 pp. $2.50. Thomas S. Rockwell Company.

An elementary story of the scientific work being carried out at the University of Chicago written by two young newspaper men. They took their formal education at the university and became acquainted with many of the scientific men. It is written in "newspaper language."

Genius and Creative Intelligence. NATHANIEL D. MITTRON HIRSCH. 339 pp. $4.50. Sci-Art Publishers.

The aim of the author is to present a psychological foundation for political and sociological theory and action. The book is divided into three parts: "History, Creative Adaptation and Genius"; "The Psychological Constitution of Man," and "An Inquiry Concerning the Nature of Genius."

Major European Governments. P. ORMAN RAY. vii + 446 pp. $3.80. Ginn and Company.

This book is intended as a starting point in the study of European governments. Each chapter has a list of "Questions and Topics" meant to encourage outside study. There is also a thirty-one-page bibliography and an index.

Mental and Interest Tests. LEO HAMILTON KING. 124 pp. $1.75. Teachers College, Columbia University.

A treatise on the evaluation and comparative effectiveness of the tests as factors of prognosis in secondary education. The author places particular emphasis on the technique of devising interest tests and on the quantitative evaluation of interest factors.

THE SCIENTIFIC MONTHLY

OCTOBER, 1931

BELGIAN CONGO SANCTUARIES

By MARY L. JOBE AKELEY, A.M., F.R.G.S.

SECRETARY OF THE AMERICAN COMMITTEE FOR SCIENTIFIC RESEARCH IN THE PARC NATIONAL ALBERT

HAVING already established the first national park in Africa, the Parc National Albert, in the Belgian Congo, Belgian conservationists are now planning to extend their unique sanctuaries for conservation and research to other fields in the Congo. Parc National Albert comprises 500,000 acres; Parc Leopold and Parc Ruwenzori, the new projects, will add, respectively, 1,000,000 and 500,000 acres to this great park system. In America, where our great national parks attract visitors from all over the world and inspire foreigners to emulation, the addition of two such areas as these would appear to have but little importance. However, the significance of the Belgian park idea lies not only in the fact that it led to the creation of the first parks in Africa, but also to the first parks in the world to be established for purely scientific purposes.

This complete sanctuary for wild life in Africa, the Parc National Albert, was established by royal decree of Albert, King of the Belgians, in 1925. Here, in the Kivu District of the Belgian Congo, near the geographic center of the great continent, are found many interesting animals, chief among which is the rare mountain gorilla (*gorilla gorilla berengei*), to-day of increasing importance, not only to scientists but also to lay students of the wilds.

On the cool wooded slopes of the extinct volcanoes and ranging side by side with the gorilla and at peace with him are herds of elephant and buffalo; here, too, are leopards which sometimes menace the gorilla's young. In the lower lands—the sandy plains and swampy lands bordering one of Kivu's great lakes, Lake Edward, are herds of antelope such as frequent the wide plains and rolling uplands of British East Africa. In the deep, slow-flowing Rutshuru River and in Lake Edward are herds of hippo thriving and increasing under a hot tropic sun.

Of all the highly diversified regions which represent all the zones of climate of the earth and which are now included in the Parc National Albert, the gorilla's wilderness home is by all means the most impressive. The landscape is startlingly beautiful. Giant forest monarchs crowd upon each other, their gnarled and long moss- and fern-hung branches touching and intertwining, their massive trunks, draped in long flowering banners of gray-beard moss or pale green vines, starred with golden flowers. Here and there, in crannies of bark or in the moss, brilliantly colored orchids flourish. Round about is an almost impenetrable undergrowth brightened by blossoms of many hues. The leafage of the forest, the masses of glistening leaves that top the great trees, gleam in the fitful sunlight in many changing shades of creamy yellow, aquamarine and emerald. Never elsewhere have I seen the foliage of a forest of so many variant shades of green.

KARISIMBI

Photo by Mary L. Jobe Akeley

ONE OF THE PEAKS OF THE PARC NATIONAL ALBERT, BELGIAN CONGO, IS FRESH SNOW. THE WILDLY BEAUTIFUL FOREST THAT COVERS THE SLOPES OF THIS MOUNTAIN AND ITS SISTER PEAKS, MIKENO AND HAGENIE, IS THE CHARACTERISTIC HOME OF THE GORILLA

This gorilla forest occurs at an altitude of 9,000 to 12,000 feet above sea-level. Once in a long while, from a vantage point on some volcanic rampart, you can see a wide and impressive view. One such was on the slope of Karisimbi, a mile from our camp, where in 1926 I spent six weeks, collecting and studying the habitat of the mountain gorilla. Here, in a break in the trees, we could see to our right the rugged massif of Mt. Mikeno. Three thousand feet below stretched the wide expanse of lava plain, an outflow in recent geologic times from the active volcanoes, Nyiragongo and Nyamlagira, whose massive cones, topped by glowing, amber-colored clouds, cut the far horizin. Below them to the southward stretched the pale blue sheet of Lake Kivu, glittering with the reflection of the glowing sun as it sank into the hinterland. It is in this environment of age-old forest that the gorilla has established his home.

The attention of scientists as well as of nature lovers was directed to this remote part of the world by the late Carl Akeley, naturalist and conservationist, following his 1921–22 expedition for the American Museum of Natural History. There in the untouched wilds of the Congo he secured a group of gorillas for a natural history exhibit for African Hall. Unwilling to take any life needlessly, he collected only five—one half the number of specimens permitted him by the Belgian Government—because he believed this number sufficient to serve his scientific purpose. While collecting these specimens, he observed the gorillas at close range and accordingly became impressed by the non-combative nature of the gorilla when undisturbed by man.

Mr. Akeley was greatly surprised by the small number of gorillas inhabiting the forested slopes of the three extinct volcanoes, Mikeno, Karisimbi and Bishoke, in which they had been reputed to be plentiful. He knew that many "mighty hunters" of big game were at that time eager to hunt and kill gorillas because they craved a new sport—new hunting trophies for their collections. Realizing that because of the nature of the gorilla and the scarcity of the animal it would be an easy matter to exterminate the whole colony, he began to advocate the protection of the gorilla as well as of all other wild life, both plant and animal. Upholding and actively assisting him in his plea were Dr. John C. Merriam, president of the Carnegie Institution of Washington, and Mr. James Gustavus Whiteley, Belgian consul general at Baltimore.

It was in January that Mr. Akeley wrote to Dr. Merriam, expressing his great desire that the Belgian Government might set aside an area wherein the gorillas might be permitted to live in complete security. He also advocated the eventual establishment of a scientific research station, located in close proximity to the gorilla mountains and the live volcanoes, with their rich and varied opportunities for study.

Dr. Merriam immediately recommended this gorilla sanctuary plan to Baron Emile de Cartier de Marchienne, then Belgian ambassador to the United States, who took it directly to King Albert for consideration. The King was impressed by the extreme desirability of the measures advocated, and in 1925 he created the Parc National Albert. This royal decree was approved and commended by individual scientists and conservationists interested in this Congo wonderland. Only professional hunters of big game were disappointed, since they could no longer kill the big anthropoids for trophies.

Scientific bodies soon voiced approval. In April, 1925, the National Academy of Sciences expressed in resolution its "gratification at the action of His Majesty, the King of the Belgians, in the establishment of the Albert National Park for the effective preservation of the

ONE OF THE PEAKS OF THE PARC NATIONAL ALBERT, BELGIAN CONGO, IN FRESH SNOW. THE WILDLY BEAUTIFUL FOREST THAT COVERS THE SLOPES OF THIS MOUNTAIN AND ITS SISTER PEAKS, MIKENO AND BISHOKE, IS THE CHARACTERISTIC HOME OF THE GORILLA

KARISIMBI

—Photo by Mary L. Jobe Akeley

—*Photo by Mary L. Jobe Akeley*

GORILLA NEST

—*Photo by Mary L. Jobe Akeley*

GORILLA NEST

gorilla and other animals, together with the protection of the flora of the region," and assured His Majesty of its "deep interest and disposition to cooperate in the realization of the benefits to science and mankind arising from this wise and generous action."

Shortly after the creation of the Parc National Albert, my husband requested Belgian permission, through Baron de Cartier, to return to the Kivu to secure studies for a painted background and accessories for his Gorilla Group stating that he had delayed asking permission to do this work, pending the establishment of the gorilla sanctuary. It was also his desire to carry on initial investigations of the gorilla in his native haunt. His request was readily granted, and this undertaking became one of the objects of the Akeley-Eastman-Pomeroy African Expedition of the American Museum of Natural History.

—*Photo by Mary L. Jobe Akeley*

GORILLA NEST

While en route to Africa in February, 1926, my husband and I went to Brussels, where we were entrusted with the royal mission to the Kivu, which empowered us to execute a general survey of the National Park; to fix on the map native villages, position of forests, bare rocky country, grass lands, cultivated land and pasture, and areas inhabited by gorillas and chimpanzees; to estimate the number of these animals; to study methods of preservation of the fauna, especially the gorillas; and to select suitable sites favorably located and naturally endowed for laboratories and residences for park conservators and visiting scientists. Later we invited Dr. J. M. Derscheid, zoologist and cartographer of Brussels, to join us in Africa to assist with this survey. After my husband passed to the Great Beyond, only three days after we reached his old 1921 camp in the gorilla forest, Dr. Derscheid's painstaking efforts made it possible for our expedition to fulfil the royal mission of the Belgian Government and to prepare a definite and comprehensive report.

Returning to Europe, I was requested by King Albert to go to Brussels, where I gave him a preliminary account of the

THE *HAGENIA ABYSSINICA* ("PAPER BARK TREE")

IS ANCIENT, HUNG WITH CLUMPS OF PARASITIC FERNS AND DECORATED WITH PLATFORMS OF VELVETY MOSS AND TUSK ORCHIDS.

—*Photo by Mary L. Jobe Updegraff*

results of our expedition. Derscheid, reaching Belgium in June of 1927, went almost immediately into military service, but he was at the same time preparing an initial report on his gorilla findings and correcting and amplifying the maps of the region between Lake Kivu and Lake Edward. In the autumn of 1928, during four weeks in Brussels at the home of Dr. Derscheid, we collaborated on the preparation of recommendations for the Belgian Government concerning the future of the Parc National Albert.

As delineated by the original decree of 1925, the park was confined to a triangular area comprising the three extinct volcanoes, Mikeno, Karisimbi and Bishoke. We now proposed that this area be extended to include the arid active volcanoes, Nyamlagira and Nyiragongo, of great interest to geologists and seismologists; that it should also include the swamps and sandy lands along the southern shore of Lake Edward and the Rutshuru River, where animal life is abundant; that certain native villages and arable lands be excluded in order to preclude the possibility of future conflict between native rights and the material development of the country on one hand and the interests of science on the other; and, for the promotion of scientific research, that there should be established a central station for research and administration, including laboratories, library and study museum, and also that ranger stations should be built throughout the park. In conclusion, we recommended that the management of the park be placed in the hands of a scientific institution so favorably situated as to obtain financial and scientific help both in Belgium and in foreign countries.

Our report, approved by His Highness Prince Albert de Ligne, until recently Belgian ambassador to America, and by Baron Emile de Cartier de Marchienne, now Belgian ambassador at the Court of St. James, was submitted with hearty recommendations to King Albert when he received us at the Royal Palace on October 8, 1928. There, throughout a long and interesting evening, the project of the park was discussed. Dr. Derscheid gave an account of the Akeley-Derscheid expedition and projected photographs of the Kivu. I had taken with me to Brussels the gorilla film which Mr. Akeley had made in 1921 in the Kivu, the first motion pictures ever made of live wild gorillas, and this also we showed to His Majesty and to His Royal Highness Prince Leopold, who had recently visited the Kivu volcanoes.

The following May came the royal decree of May 6, 1929, which increased the Parc domain to 500,000 acres, and provided therein for the preservation of all fauna and flora for strictly scientific purposes. The newly added territory included Lake Edward, in the northern part of the Kivu District. Lake Edward is much lower in elevation than the gorilla country. Its shallow, turbid waters teem with animal life; its shores and adjoining grassy, sandy plains are hot, affording range lands for large herds of antelope, all the species found in East Africa, and found nowhere else in the Congo; its swamplands and affluent rivers harbor herds of hippo (*Hippopotamus amphibius kiboko*).

The decree of 1929 also stipulated that the Parc is to be administered by the Commission du Parc National Albert, under the presidency of His Highness Prince Eugene de Ligne, and by a committee of direction. In the park, it is forbidden under penalty of penal servitude, or fine, or both, to pursue, capture, kill or molest in any way any kind of wild animal, including animals which are reputed harmful; to take or destroy the eggs of wild birds; to cut down, destroy or remove any uncultivated plant; or to make any excavation, embankment, boring or any operation of a nature to change the aspect of the ground or of the vegetation. Unless provided with a

—*Photo by Mary L. Jobe Akeley*

M'GURU, GORILLA GUIDE

IN MOSS-COVERED TREE, WHICH WAS BROUGHT TO AMERICA BY MRS. AKELEY AS AN ACCESSORY FOR THE GORILLA GROUP FOR AKELEY AFRICAN HALL.

special permit, no one (except officials and others properly qualified) may enter the park, or circulate, camp or sojourn therein, or introduce dogs, traps or firearms, or possess or transport or export skins or other parts of wild animals, or uncultivated vegetable products. Lands now occupied by natives or private persons are to be expropriated. Even on these tracts under private or native occupation, the destruction, capture or pursuit of the gorilla as well as all forms of hunting this animal are absolutely forbidden.

Around the park proper are areas which serve as a protecting zone. Cutting down trees, hunting and fishing are prohibited in this zone. A few natives now living therein will not be deprived of their hereditary rights, but they may employ only their primitive weapons. The Belgian Government will pay the strictly administrative expenses of the park, maintaining a corps of conservators and native police.

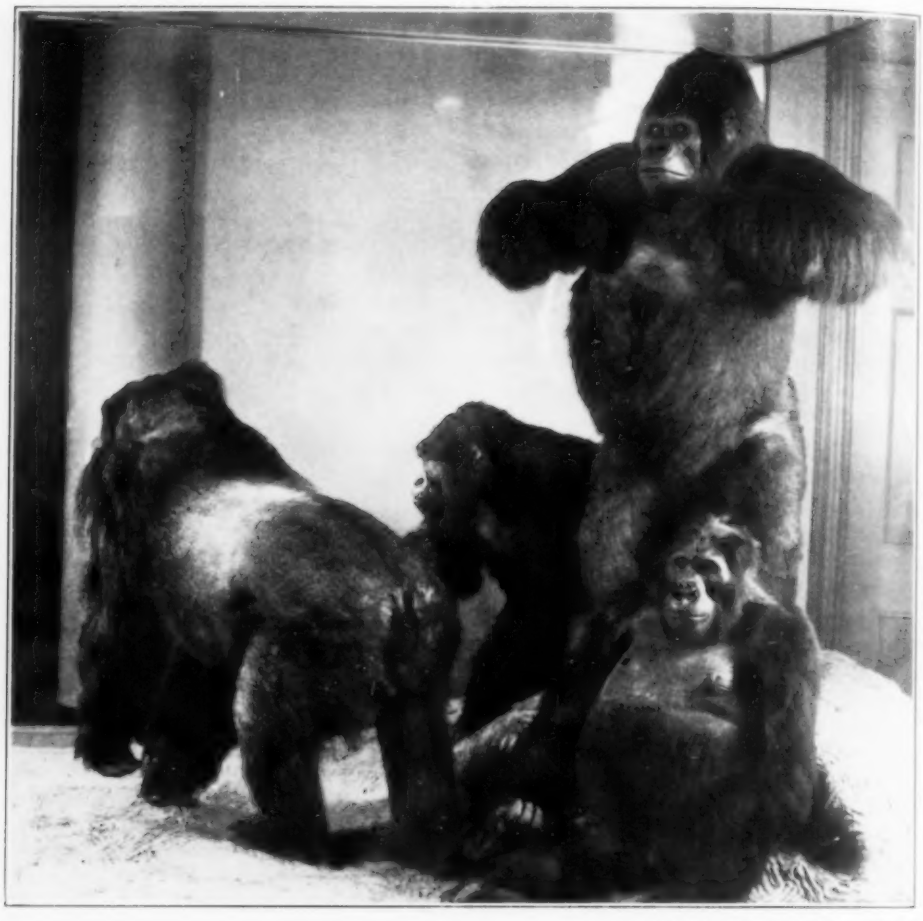
In October, 1929, King Albert formally installed the Commission du Parc National Albert, which is a body of eighteen scientists chosen from England, Sweden, the United States, France, the Netherlands and Belgium. In his address at the Palais des Academies, Brussels, His Majesty described the park as unique because of its widely diversified scientific opportunities. He emphasized the varied aspects of the region which are of interest not only to geologists and mineralogists, but which are remarkable from the point of view of ethnography as well, since Bantu and Hamitic tribes as well as pygmies (Batwa) are simultaneously present; and by no means least remarkable, from the point of view of biology, since the wide range of its altitudes allows several life zones to meet and gives rise to flora and fauna infinitely rich and varied.

"No other region of the African continent," said His Majesty, "offers such wide opportunity for scientific study and for the installation of scientific research stations which would be easily accessible in a climate ideal for the white race."

Then, in 1930, the American Committee for the Parc National Albert was formed to cooperate with the International Committee in the work of scientific research. His Highness, Prince Albert de Ligne, at that time Belgian ambassador at Washington, who from the beginning has taken an active and energetic part in forwarding the plans for the Parc, was named by His Majesty chairman of the American committee; Mary L. Jobe Akeley was appointed secretary. In addition to the two American members of the International Commission, Dr. Henry Fairfield Osborn and Dr. John C. Merriam, Prince de Ligne has appointed as members of the committee Mr. Stanley Field, president of the Field Museum of Natural History, Chicago; Dr. Vernon L. Kellogg, of the National Research Council, Washington; Dr. Robert M. Yerkes, of Yale University; Dr. George W. Crile, of Cleveland, and the Hon. James Gustavus Whiteley, Belgian consul general at Baltimore.

At a meeting of this committee, held recently at the American Museum of Natural History, New York, Prince de Ligne, who was leaving America to take up his duties as Belgian ambassador at Rome, resigned his office. Dr. Merriam was elected president to succeed him. At this time, it was decided to enlarge the American committee in order to afford a national representation. The committee's purpose now is to bring the Parc National Albert and other similar undertakings in Belgian Africa in closer contact with American scientific and conservation organizations, as well as to secure support for these projects.

Dr. J. M. Derscheid, now administrator-general of the Parc, was present at this meeting and reported to his colleagues plans for the further extension of the park system in Belgian Africa,



—*Photo by Mary L. Jobe Akeley*

GORILLA GROUP IN AMERICAN MUSEUM OF NATURAL HISTORY
MOUNTED BY CARL AKELEY.

and told them of the progress of the Kivu park. In addition to the Parc National Albert, there will be created a new park, Park Leopold, near the northern border of the Congo. It will comprise an area of 1,000,000 acres. Lying north and east of Parc National Albert will be another new park, the Parc Ruwenzori, an area of 500,000 acres in the Ruwenzori Range, adjoining the Belgian Congo-British Uganda Boundary. These new regions are of particular interest to scientists since they are the home of such rare mammals as the white rhino (*Ceratotherium cottoni*); the okapi (*Okapia johnstoni*); the giant Derby eland (*Taurotragus gigas*); and lechwe, Mrs. Gray's antelope (*Onotragus megaceros*). Here also occur such interesting birds as the secretary bird, (*Sagittarius serpentarius*); the hornbill (*Lophoceros melanoleucos stegmanni*); the Gelo River crowned hornbill (*Pophoceros melanoleucos geloensis*); the Ruwenzori lourie (*Ruwenzoriis johnstoni johnstoni*); the Uganda brown parrot (*Poicephalus myeri saturatus*); the Southern little bee-eater (*Melitto-*

phagus pusillus meridionalis); the Ruwenzori Kakelaar or wood hoopoe (*Phoeniculis purpureus ruwenzorae*); the Swahili wood owl (*Strix woodfordii sahelica*) and many others.

Pending the official establishment of these new parks, activity has been concentrated in the Parc National Albert. Patrols of native scouts are on guard to prevent the killing of any wild animal and the destruction of plant life. Meanwhile the Belgian Government has appropriated ample funds for the maintenance of the Park Service, and has advanced a loan of two million francs, to begin immediate construction of a central station for scientific research. This station will be erected on a grant of twenty acres in the heart of the government post at Rutshuru. The buildings will rise on the banks of the deep-flowing Rutshuru River, and will give a broad view of both active and extinct volcanoes. The station is in the geographic center of this naturalist's paradise.

Here will be the central library, containing a collection of all the scientific treatises relating to the fauna, flora and geology of Central Africa; a study museum, for which will be collected all the animals indigenous to the immediate vicinity; laboratories, equipped for the use of zoologists, botanists, seismologists and geologists. Adequate provision, as well, is being made for a chemical laboratory and a photographic wing. Nearby will be an assembly hall, administrative offices and living quarters. All these buildings are designed for the use of white men unaccustomed to the tropics. Although barely one degree from the equator, Rutshuru is actually white man's country, because its 5,000 foot elevation brings it out of the torrid zone.

This central station, moreover, will very shortly be connected with the outside world by a motor road to Redjaf-on-the-Nile, and thence by water and rail to the Mediterranean. Another road will connect with Kisumu, and thence by train to Mombasa, the port of entry on the Indian Ocean. However, quickened avenues of approach to this region will by no means result in letting down the barriers into the Parc, so far as the outside world is concerned. One of the most important points in the scientific creed of the Parc is that therein the primitive shall be preserved! Accordingly, the natural conditions in the Parc will not be disturbed by contact with grazing or agriculture; and, lest the fauna become half-domesticated by the familiar presence of man, certain limited areas will be set aside, free from human intrusion except as emergency may require.

In our great American national parks, animals are all too often semi-domesticated. Bears, demanding sweetmeats or manufactured food, "hold up" passing

PROPOSED RESEARCH STATION

TO BE BUILT IN THE PARC NATIONAL ALBERT, BELGIAN CONGO.

motor cars; they live in the main on hotel refuse, and are in many ways changed from their primitive ancestors in general behavior psychology and even in physiological habits. Such a state of affairs will never be permitted to exist in the Parc National Albert. Only scientists will frequent the Parc, and even they are barred from at least one quarter of its area. Thus, the gorillas of that region, as well as other wild species, will not become accustomed to man, and thereby influenced or changed by contact with him.

This intention to preserve the primitive, wholly unaffected by the aggressive march of civilization, is indeed a recent attitude. It is the spirit motivating those who now carry on the fight to save vanishing Africa. Theirs is not a sentimental interest. It is a sympathetic understanding and a realization of the urgent need for action. In Africa, at least, Carl Akeley's dream, now become a reality, has halted the juggernaut of mass destruction. Belgium's wholehearted response is an epochal instance of the international possibilities of conservation and of scientific inquiry. Such liberal and broadminded action will go far toward cementing national friendships.

Thus, through an action of extreme generosity and cooperation, the resources of Belgium's scientific wonderland in the Congo have been thrown open to scientists from all over the world. We are confident that they will not be slow to take advantage of these unparalleled opportunities for serious research. Furthermore, it is earnestly hoped that sympathetic laymen, in America as well as elsewhere, will come forward to assist in the rapid completion of the great central station. Such practical and friendly support will be at once an aid to the progress of science and an important material contribution to the conservation of wild life under conditions of rare and compelling interest.

SOME OF THE BIOLOGICAL EFFECTS OF DROUGHT[1]

By Professor HARLEY J. VAN CLEAVE

UNIVERSITY OF ILLINOIS, URBANA

MANY conservation agencies have been active in calling attention of the public to the peculiar problems confronting the movements for conservation growing out of the period of excessive drought which spread over large portions of our country during the summer of 1930. Through the agency of the U. S. Biological Survey, information on the dire effects of drought upon the water fowl in their nesting sites has been pictured, and a decrease of at least 50 per cent. in the season's hatch of water fowl has been estimated for some of the most favorable breeding grounds. Likewise, the U. S. Bureau of Fisheries has given forth information on the effect of the dry season upon the fish life of our lakes and streams. The American Game Protective Association has given publicity to the appalling situation with regard to the larger game mammals and birds. Furthermore, many other investigations carried on by federal and state agencies and by private individuals combine to give the public a fair basis for understanding that a definite crisis faces all our larger species of wild life as a consequence of the extreme drought which, in many parts of the country, extended throughout the summer and winter of 1930–1931. Little has been recorded of other aspects of this problem because the public is interested chiefly in the game birds and animals; for conservation to many people means only the protection of the interests of the hunter.

Important as this aspect may be, the biologist views the larger creatures such as the game animals, birds and fishes as only links in the complicated chain of relationships which exist between all the forms of life in a given region. Consequently, to the student of biology, the effects of a severe water shortage are but imperfectly measured if only the large, conspicuous animals are considered. The importance of the smaller organisms, even down to the microscopic plant and animal life, in the food chains of all animals, makes it especially important that these less conspicuous beings should receive consideration in any adequate picture of the effects of drought.

To most people it might seem that first man, then vegetation and aquatic life are the chief if not the only drought sufferers in nature. A zoological collecting trip through southern Illinois during September, 1930, gave pronounced evidence of the effects of continued dry conditions upon some of the less conspicuous forest animals. Previous studies had shown that the region visited had been especially favorable for the development of two types of animal life which might be especially susceptible to the effects of prolonged drought, namely, the land salamanders and the land snails. Exact quantitative data are not available for a comparison between normal and drought years. But the contrasts were so evident that it seems worth while to record them here, even though numerical data are lacking. In woodlands (chiefly oak, hickory and maple) with considerable amounts of down timber that has been lying on the ground for some time, the soil and accumulated humus beneath logs provide an especially favorable habitat for land salamanders and land snails. In a normal year ten or fifteen minutes of examination beneath logs might, on the

[1] Contributions from the Zoological Laboratory of the University of Illinois, No. 403.

average, yield one or two salamanders and perhaps a dozen snails. Woodlands of southern Illinois where such collecting conditions have been known to exist previously were revisited in September, 1930, and in numerous examinations over a wide area covering a period of five days, a single salamander was seen and a total of not more than a dozen living snails was observed. Dead snail shells were taken in great abundance, and especially those from under logs gave mute evidence of the extent to which mice and other rodents had preyed upon the snails seeking shelter beneath logs where the last vestiges of available moisture were to be found.

Recent rains had furnished sufficient surface moisture on the floor of the forests to stimulate activity of the snail population if the snails had been simply estivating. The lack of active snails and presence of dead shells gave conclusive evidence that the land snail population had been very seriously decimated as an accompaniment of the drought and conditions associated with it. By way of an attempt at expression of relative abundance, the living snails were estimated as present in numbers less than one per cent. of the numbers present in the same habitats at the same season following a favorable summer. The failure to find salamanders in usual abundance might be explained by the greater readiness with which these animals may migrate from unfavorable conditions. It is entirely possible that crevices or mouse runs, especially in ravines or in the vicinity of springs, may have sheltered salamanders and account for their absence from their usual habitat. Though extended search was conducted for such refuges, none were found.

Fire as an accompaniment of the drought conditions added to the severity of toll of life in many localities visited. The tinder-like grass and dead vegetation when burned gave eloquent testimony of living sacrifices to the god of rain or the demon of fire. Charred bodies of snakes and rodents were seen in the burned-over areas, dried mummies of salamanders were found under stones and logs, and burned, fragile snail shells were strewn among the lifeless ashes.

The right-of-way along railroads has for some time been proclaimed as sheltering a surviving remnant of our typical prairie flora. The railway embankments themselves are not a relict of primitive conditions, but on the contrary furnish a highly artificial set of conditions provided by the grade and the largely foreign ballast material. Even after the period of excessive drought, the roadside, the railway right-of-way and even the artificially formed embankments provided more favorable conditions for the collection of living land snails than were discovered in any of the natural wooded areas studied. The excessive exposure to sun and wind, and the poor conditions for retaining moisture would seem to render the railway embankment decidedly unfavorable, but here living land snails were found in abundance sharply in contrast with that of woodlands and meadows. Chiefly nocturnal in habits, these snails during the day seek shelter under pieces of wood or bits of stone. In one instance a piece of wood about 3 by 5 inches served as the shelter for more than 60 living snails, most of which were at least 8 mm in diameter. The species of snails living in this new habitat are by no means limited to a few. They are the forms of the region which previously were characteristic of the meadows and woodlands. They include several species of Polygyra and Gastrodonta, as well as numerous species of the smaller pupoids and zonitoids.

Though drought seems to have exercised little influence upon the snails along railway embankments, fire had imposed a heavy toll of life. Many dead animals were found on portions of the right-of-ways that had been burned

SOME OF THE BIOLOGICAL EFFECTS OF DROUGHT

FIGS. A AND B. THE SITE OF HORSESHOE LAKE IN SOUTHERN ILLINOIS AFTER THE WATER HAD COMPLETELY DISAPPEARED. THE TREES IN THE BACKGROUND MARK THE LOCATION OF THE ISLAND. PHOTOGRAPHS TAKEN IN SEPTEMBER, 1930, BY MISS HILDA STEIN.

FIGS. C AND D. RESULTS OF COMBINED ACTION OF DROUGHT AND POLLUTION ON SNAIL POPULATION OF THE ILLINOIS RIVER ABOVE PEORIA. IN FEBRUARY, THE HEAPS OF SHELLS WERE MUCH HIGHER THAN SHOWN IN THESE PICTURES WHICH WERE TAKEN IN MAY.

over as per custom of railway maintenance. In such regions only an occasional survivor was found beneath stones or heavy timbers. Repopulation of these burned areas must come largely by invaders from the surrounding unburned areas. Advocates of conservation have here an added argument in favor of repeal of state laws and regulations stipulating that railroads must periodically burn over their right-of-way, for not only is the remnant of our native flora thereby endangered, but all sorts of animal life suffer at the same time.

The effects of the drought in many regions of central and southern Illinois were no less pronounced for the aquatic life than for terrestrial beings. In many regions streams and ponds which have been considered permanent were wholly dry since early in June or July and remained dry until in March. For these the drought conditions spelled practically the extermination of all forms of aquatic life. In many instances, all the fish life, even including the game fishes, was wiped out from entire lakes, ponds and streams. Unfortunately, little was done in the state of Illinois to avert such catastrophes. One of the major casualties was at the site of Horseshoe Lake in southern Illinois near Cairo. Here a state conservation preserve, comprising 1,335 acres of water surrounding an island of 1,172 acres, became the most desolate monument to the effects of drought and failure to apply adequate rescue programs. As reported in a communication to *Outdoor America* for December, 1930, this lake with its inestimable promise as a region for perpetuating natural conditions in the Ozarkian region of Illinois disappeared completely, and with it went the lives of millions of fish, to say nothing of all the other aquatic animals which it sheltered.[2] Here before the catastrophe of 1930, fishes, birds, snakes and turtles were in the greatest abundance that the writer has ever observed in any area within the state of Illinois. The bleached bones of all but the birds, and the shells of mussels and crayfishes which strewed the former lake bed in September gave corroboration of the graphic descriptions of the death and putrefaction described by those residing close to the lake, and spoke eloquently of the myriads of smaller forms of life which must have perished at the same time.

Even temporary ponds which play such an important rôle in the life of amphibians and crustaceans, especially the fairy shrimps, have remained dry throughout the summer and winter and have not afforded the customary habitats for the breeding of salamanders and other early spring amphibians. The burrowing animals, such as the crayfishes and earthworms, doubtless have an important part in creating conditions for the carrying over of stock for temporary ponds, for they often construct burrows which deepen to ground-water level as the ponds dry up. Thereby numerous forms of animal life doubtless find refuge and remain as a stock to repopulate the pond when surface water makes its appearance and through the worm or crayfish tunnels brings the ground water again in continuous relation with the surface water.[3]

Press reports throughout the summer and winter of 1930–31 cited many instances of failure of wells and reservoirs and the serious curtailment of water

[2] Word has been received that the Department of Conservation of the state of Illinois has constructed a new dam at the Horseshoe Lake site and that plans for restocking the new lake are under way.

[3] Since the above was written, the author has seen the very interesting memorandum by E. P. Creaser "Some Cohabitants of Burrowing Crayfish," *Ecology*, January, 1931. This short note is one of the most significant contributions to an understanding of the method of repopulating temporary ponds and of the establishing and distributing of subterranean aquatic faunas.

supply for household and industrial purposes. The inconvenience and the economic losses incident to the failure of a water supply are clear to the minds of most people, but little has been said of the biological significance of such water famines. One instance has been studied in more than usual detail by Dr. David H. Thompson, of the Illinois State Natural History Survey. For a civic water supply the city of Mattoon, Illinois, depends upon a reservoir of approximately 175 acres, known locally as Paradise Lake. This reservoir was known as an especially favorable habitat for fishes, and earlier surveys had revealed a rich and varied population. By March, 1931, the water area of this lake had been reduced to less than 10 acres. At this stage, Dr. Thompson made a survey of the fish life and has given consent to the use of some of his unpublished observations. He found that in the biological struggle that accompanied the shrinkage of the waters all the small fish had disappeared, and none but the large game fish survived. Eye witnesses of the progressive stages are not required for the reconstruction of the scenes in the struggle of elimination and survival which accompanied the restriction of the habitat. Competition for the natural food supply on the forage grounds gave way to predaceous habits and cannibalism which terminated in the survival of a few individuals out of the varied population. Similar reductions and complete exhaustion of stored water supplies were reported from many regions throughout the drought area. Every instance must have been marked by corresponding reductions in the animal life, though human inconvenience and economic losses loomed so large in the picture that few could look beyond them to an appreciation of the losses to conservation.

In discussing the effects of drought upon terrestrial habitats, attention was directed to the responsibility of fire of human origin for depopulating faunas already reduced by the direct effects of drought. Similarly, in the aquatic habitats, the dire consequences of reduced water levels were multiplied many times over by the addition of sewage to the waterways. Rivers which have been able to carry a heavy load of sewage in normal years digesting the raw sewage and becoming self-purified as the water proceeded downstream were hopelessly unable to carry the same loads with decreased water flow. The Illinois River, for example, in the vicinity of Peoria, Illinois, was transformed from a river into an open sewer as an accompaniment of the drought of 1930. The sewage from Chicago could not be digested and consequently settled as accumulations at the bottom of the stream bed in all the quiet stretches of the river. These settling basins, acting exactly as settling tanks in a modern sewage treatment plant, were flushed out with each increase in diversion of lake water into the river and later in the winter by the rains and snows. In consequence, the putrid undigested sewage of Chicago was relayed by stages to regions far below the points where natural purification of the stream has occurred in normal seasons.

The total effects upon the animal life of the Illinois River are hard to estimate. Fishermen in the vicinity of Peoria report an appalling decline in the yield of commercial nets. A survey of the Illinois River from Peoria to Rome, Illinois, late in February, 1931, revealed conditions of low water and pollution that are hard to visualize. For miles at a stretch the stream in receding to a narrower channel had left wide margins of sludge banks whose filth was devoid of all evidences of life excepting those forms which live normally in sewage tanks and heavily polluted waters.

Because of the many cyclic factors

influencing the population of this river, as shown by the intimate studies of Forbes and Richardson covering more than four decades, exact quantitative expression of the combined effects of drought and pollution in the destruction of life is impossible. One of the most compelling evidences of the consequences of pollution of the Illinois River by sewage under the contributory hazard of low water is the countless number of dead snail and mussel shells lining the shores of the stream. From the city of Peoria northward, the receding waters throughout the winter have been heaped with drifts of dead shells. In February, 1931, these drifts were practically continuous shell heaps for the ten miles of the stream examined. Where wave action had not scattered the shells and where sludge had not buried them, the heaps of dead shells alone were frequently more than a foot deep and were more than two feet through at the base. The large, banded viviparous snail (*Viviparus contectoides*) was the most plentifully represented in these shell heaps, though numerous other species of snails and many bivalves were present. Of the snails, the gill breathers were the most seriously affected, in all probability because of the fact that the heavy load of sewage carried by the river used up all available oxygen, thus causing suffocation of the branchiferous animals. Several species of organisms which are known to be highly tolerant of sewage pollution were found living in the river. These included some of the pulmonate snails and fingernail shells.

Undoubtedly, pollution has been largely contributory to the loss of life of many kinds of aquatic organisms which might have been able to withstand the lowered water level brought about by the extended drought.

In conclusion, we know that many regions where moisture is lacking have characteristic faunas and floras adapted to the peculiar condition of the lack of water. The organisms which live habitually under these circumstances show many and varied adjustments to their surroundings. It is a common experience that organisms not adapted or adjusted to xerophytic conditions do not ordinarily survive long when introduced into them. For this reason, the excessive drought of the summer of 1930 holds much interest for the student of biology as a means of interpreting the effects of sudden and radical changes in the environment upon the life of the region affected. The process of natural adjustment to xerophytic conditions can not take place suddenly. In those forms which show natural adjustment, the change has doubtless been slow, either paralleling the changes in the environment itself or brought about as gradual modifications in organisms invading the area from surrounding regions of more nearly normal moisture conditions. The chief observable result of unusual periods of drought seems to be the material reduction of natural populations among the native species of animals. There is no apparent selection toward survival of the fittest in a single season. Consequently, the chief biological effect of a period of excessive drought is the imposing of a period of extreme depression in the population of all species affected. Such a period of depression will doubtless be of great influence in modifying the periodic cycles of increase and decrease in natural populations that have been so frequently observed by students of nature and correlated more or less satisfactorily with astronomical and meteorological periodicity. It remains for future studies to determine whether the reduced populations following the 1930 drought comes as one of the normal cyclic periods of population reduction correlated with major meteorological cycles or is an accessory period of depression imposed upon the normal periodic cycle in range of abundance of living things.

UNITS OF ENVIRONMENT

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For more than a decade it has been a considerable part of my business to give attention to environment and to problems of tracing and explaining environmental relationships. In practice, I have found it necessary to select as a point of departure some object or group of objects, and to examine a limited number of other objects, together with a limited number of entities and influences in relation to it. Under such limitations it seems impossible to avoid treating these particular objects, entities and influences as though they were units in the environment or units of the environment.

On the other hand, if I turn my attention to the general idea of environment, it becomes evident that there are no units either in or of environment. Exasperating and impractical as this view of the situation may be it yet has the merit of suggesting caution when one becomes too greatly impressed with his success in following clues to controlling influences.

So far as any thing or group of things is concerned, the universe is divisible into two parts, the thing itself and its environment. Constituting the universe as they do, these two parts are not wholes, but fractions having very essential relationships to each other and to the whole completed by them. If the thing designated be an electron, perhaps one may say that the thing (self) is indivisible while its environment is indefinitely divisible, but both are fractions of the universe, none the less. In other words self and non-self compose the universe, all that is not one being the other.

If one examines a thing different from himself he becomes a part of environment as far as that thing is concerned. Often he is the most important feature in study of environment, sometimes because he modifies the natural relationships between the particular self and environment and sometimes because he assumes that he has solved the problem of these relationships before he has reached comprehension of their extent or intricacy.

For single living things, or for any particular group of living things environment is so nearly the whole universe that it might be treated as a whole in practice were it not for the extreme ranges of differences amongst the parts into which it is divisible, differences in character, differences in degrees of influences depending on power, magnitude, duration and distance, and differences in directness of application of influence. These differences in the fractional parts of environment are both qualitative and quantitative and in respect to any particular situation it is often true that certain fractions carry great influence through their qualitative character rather than through their quantitative prominence.

Not least of the difficulties to be encountered in any and every attempt to assign numerical values to selected fractions of the environment is the impossibility of finding a system of measurement common to all. Supposing I observe a thousand increases in abundance of diatoms, from which I conclude that temperature is the "dominant factor" (fraction, in this context). My conclusion is based on a series of coincidences of evidences of increase in abundance with evidences of change in temperature within limits of what we call degrees, whereas heat may be only one of several influences acting together or nearly so. As a matter of fact there is not, even for other forms of radiant energy which may accompany heat, a system of measurement which enables us to compare ac-

curately quantitative expressions of their separate influences on abundance. Still less are there systems of measurement which enable us to make quantitative comparisons between temperature and numerous chemical and biological influences. If we had such systems we might find that although temperature seemed most prominent its actual influence in promoting abundance was less than that of some other fraction operating jointly or at the same time.

In this connection we confront another difficulty which might not be wholly relieved by any harmonization of systems of measurement, that is, that temperature in a case like that mentioned may exert much of its influence in a roundabout-way through affecting closely associated physical and chemical fractions, or through affecting abundance and activities of closely associated organisms of other kinds. Similar reflexions of influence are also more or less distinctly characteristic of all other fractions in their relations to any particular self. Indeed, there is good reason for thinking that at times the reflected or indirect way of influence is most important. For example, rising temperature in spring may directly favor the growth of herbage in a mountain meadow, but the indirect effect through preventing entrance of grazing stock by torrential streams across its entrance due to melting snows may be still more favorable.

Then, again, one must remember that the question is not confined to environment, the word meaning nothing unless influence is delivered as well as exerted. That is to say, the picture is not complete unless the effect on or in self be measured as definitely as the influence directed toward self. In many cases one of the effects on or in self becomes a means of increased activity in some fraction of the non-self. For example, release of excess oxygen by diatoms may enable certain animals near them to release more carbon dioxide which enables the diatoms to release more oxygen.

Here we arrive at the problem of the wholeness of self or the boundaries between self and non-self. Even in the case of an individual man it seems obvious that the distinction is not sharp. For one thing there is the constant interchange of gases, a steady contribution of carbon dioxide to the non-self, a steady income of oxygen from it. At exactly what point does an atom of oxygen become self or an atom of carbon dioxide, non-self? Is it always safe to ignore this continuity in studying environment? How can such continuity receive proper recognition in a study of relationships?

Not only is self a fraction of the whole constituted by its self and non-self, but if it be an organism it is itself composed of fractions having recognizable importance in many problems of relationships. To mention a single example, there is the thyroid gland of higher animals which favors trends of relationships of specific type when in its so-called "normal condition," and which causes or permits wide divergences from this trend when injured or diseased. What is the possibility of finding quantitative expression for the influence of this and other fractions of self in establishing or continuing any observable set of relationships to non-self? If there be no possibility of quantitative expression what is to be our standard of values for qualitative expressions?

So far I have spoken of self and non-self with little attention to time, only a few vague references, in fact. But consideration of time is essential in any practice of examination of the relationships of self to non-self, especially when self is an organism. Furthermore, the part played by time in these relationships is not simple. First, there is the time of existence (age) of the self organism, the part which it takes in producing any combination of relationships is different in youth from what it is in maturity, and the responses to contact with particular fractions of environment are different in the two periods. Second, there

is the duration of time of contact of particular fractions of non-self with the self, brief contact producing no observable result in cases similar to those in which remarkable results are observable after longer contact. Third, there is the time required for results to appear after exposure of self to certain influences of environment. Fourth, there is the rate of change (lapse of time between successive, observable changes) in relationships between self and non-self. How is time to be treated in discussion of all relationships? So far as I know, the only attempt to give quantitative designation to time in environmental studies is through use of divisions of calendar time. Since there is no true measure of time, might it not be more appropriate in some cases to use divisions of the cycles or rhythms of existence of selves in attempting quantitative expression of time? But, if that were undertaken, how should we establish a basis of determination of such divisions which might be intelligible to all of us?

So much by way of illustration of numerous abstractions in connection with questions of units of environment, which are too important to be ignored but also too elusive to be utilized in ordinary practice under present limitations of knowledge. I propose now to examine the question of units in aspects more closely related to ordinary usage. If one undertakes to study the ecology of an apple tree, he is likely to regard it as a unit surrounded by units of concrete type and by influences representing units of immaterial or distant type. In careless moments he may be speaking of a neighboring tree as a unit of environment at the same time that he speaks of temperature or air as a unit of environment. Again he may speak of a forest or of a valley as a unit of environment, meaning thereby that an aggregation of trees or an area of land is a part of or sample of environment which he intends to treat as a unit for particular purposes. If the single apple tree is the cause of mention of this particular list of features of environment he may give main attention to the effect of competition for soil by the neighboring tree, to certain extremes of temperature peculiar to the spot, to the humidity of the air, to the breeding of insect pests in the surrounding forests, and to the air drainage of the valley, thus indefinitely confusing influences with sources of influences, and comparing direct and positive influences with those of indirect, or diffuse, or highly composite character.

As I wish to give some time to the problems of mensural units I will not follow the preceding line of suggestions any further at present. Judging from my reading of articles on ecology it is generally assumed that degrees of temperature by either Fahrenheit or Centigrade scales are accurate measures of changes in influence of heat in the course of ecological investigations. Even if these measurements be satisfactory when used with proper precautions, allowances and reservations, it is probable that in ordinary usage they are not fully dependable and that they may be actually misleading. In the first place it is well known that organisms in nature are affected by other forms of radiant energy which accompany heat, but which are not measured, even light frequently going unmeasured in terms comparable with degrees. Furthermore, the fact that the degree of heat expended (or delivered to a certain spot) is not necessarily the degree of heat effective in any particular activity of the organisms is usually ignored. In addition, I rarely see any record of the energy relationships of heat accompanying the records of degrees. In discussing biological relationships none of these records have much value alone. Records of periods of duration and contact are often equally important. Confidence in the sufficiency of the mere record of intensity of heat by degrees appears to be most

strongly shown by some of those experimenters who seek to maintain so-called "constant temperatures" in studies of organisms, a state of affairs radically different from that surrounding organisms in nature, and also radically different in the trains of relationship following its establishment in rigid contact with the organisms.

Evidences of the influence of temperature differ extremely with different organisms. I have seen buttercups blooming in the edges of snow banks amidst many other kinds of plants still dormant. This suggests the existence within the buttercup of a mechanism for a certain amount of control of temperature. If it exists in the buttercup, why not in other organisms? If it exists in any organism should it not be evaluated whenever the influence of change in heat intensities is discussed?

I am indebted to Dr. Burton E. Livingston for full realization of the fact that neither ecologists nor experimental biologists have any method of expressing the differences in influence between a ten-degree rise and a ten-degree fall in temperature, or of showing a whole series of differences in effects of fluctuations of temperature in relation to duration of periods of rise and fall. It is not uncommon, however, for observers to attempt to express the temperature relationship in terms of averages of degrees. It seems as though we should at least try to improve this situation. The problem of differences in the effects and evidences of effects in waxing and waning influences is not confined to temperature. It belongs to many other influences as well.

So, also, does the problem of lag in evidence of influence. I notice that some papers on ecology show commendable caution in respect to this point, but I am not so sure that others do. If a hot wind strikes a group of several different kinds of plants, some may show wilting or withering immediately, while others show little change for several days, although they may eventually perish. Perhaps all of us are willing to agree that the results of a particular influence may become distinguishable in widely differing periods of time, depending upon the age, vigor, activity, location and numerous other qualifications of the individual organisms, upon the intensity, amount, direction of contact, nature of contact, and duration of the influence, and upon the favorable or unfavorable trends of the concurrent actions of other influences. Therefore, it seems that we should not consider a record of temperature (or of any other measured influence) as being complete without attention to the possible lag between the recorded condition and its recognized result.

Assuming that what I have said about temperature may represent fairly well the more prominent things which I might say about other features of environment to which we attempt to apply some standard system of measurement, I will try a few suggestions regarding biological features of environment. One method of measurement of biological features rather commonly used is that of individual enumeration of organisms or aggregations of organisms, the size of the number serving to indicate the extent of the influence. Obviously, this method of measurement may be meaningless in many cases, *e.g.*, one of my little cassia seedlings was stripped of its leaves twice last summer, half a dozen big caterpillars doing most of the damage on each occasion. If six could strip it, the information that a dozen smaller caterpillars were also active would be misleading because destruction of foliage might have been complete without them. Furthermore, it is important to note that the big six were doing more damage than the whole eighteen on the first day after hatching from the eggs. Mere enumeration gives no clue to progressive changes in influence such as this. And when in-

dividual organisms are adopted as mensural units of influence it is necessary to limit comparison to other features of appropriate magnitude or else to establish a common basis of comparison. This is often impossible. A million plant lice may kill an apple tree which might also be killed by a single rabbit, but comparison of the lethal influences of the two types of organisms by enumeration would be very difficult. However, enumeration of individuals is the most nearly dependable of any method available for use in many studies of biological influences in or by populations.

So far as I know mass measurement of organic influences is mostly useful in handling problems of large magnitude (actually or theoretically), *e.g.*, the spread of a blight designated in acreage or the advance of an insect pest into new territory designated in miles or square miles. In my work I have not had much use for this method.

The measurement of influences of serums and toxins by effects of certain volumes, dilutions or concentrations on test organisms was regarded as a dependable method for a number of purposes a few years ago, but there is not so much confidence in it now if I understand the situation correctly. Still it has so great advantage for important types of work involving specific attention to interrelationships of particular organisms that it must be considered practical when properly used. However, so far as my information goes, no dependable mensural units exist for this method, the possibility of error in a given measurement existing in the origin of the substance, in the official test applied to a sample of it, and in its application. A poison derived from one animal or plant may differ in strength from that derived from a neighboring (not to mention distant) individual of the same kind. Of a group of organisms of the same kind used to test its strength one may be more susceptible than another and a given test organism may be more susceptible at one time than at another. Finally, the organism to which the poison is given may be highly susceptible while another of its kind is not, or there may be a difference in susceptibility in the treated individual according to time. A well-known example of difference in individual susceptibility is that in relation to bee sting, some men being indifferent to a single sting while others are made seriously ill by one.

Apparently there is no method of measuring a biological influence with an accuracy comparable to that of measuring heat intensity, and there appears to be even less possibility of measuring the relative effects of a biological influence and an influence such as heat when both are producing observable effects in the condition of an organism. Yet it must be evident that in many trains of circumstances subject to observation there are particular biological influences holding importance second to none.

I fear that my remarks so far have served mainly to qualify me for a position as a messenger of gloom so far as accuracy in quantitative terminology in discussing environmental relationships is concerned. But to offset this possibility I think it is only necessary to call attention to the large body of literature of ecology which has succeeded in conveying ideas of high practical value from one person or group of persons to another. Our savage ancestors succeeded in living effectively with few tools of very crude type, including language. They did the best that they could with what they had until they could get better, and I believe that is what we should do.

One point greatly in our favor is the strong tendency of environmental influences to flow steadily in definite channels guided by cyclical changes in our solar system. On this account many influences acting at fairly constant intensities keep a course approximately

parallel, so enabling us to ignore them for many types of investigations. Thus we are relatively free to give our attention to influences of more irregular type, some of which we may choose to designate as dominating or determining, although their prominence is often dependent on one or more of those of regular type or on a preceding series of influences favorable to development of their prominence.

Whatever the impression received from my imperfect and rather superficial discussion of quantitative devices for handling ecological problems, I hope it will be clearly understood that I believe ecologists have had much commendable success in conveying ideas with very crude equipment, that we are making improvement in this equipment and the methods of using it, and that we can hope for still better results if we compare experiences and use them as a basis for concerted effort at further improvement.

THE RELATION OF MAMMALIAN DISTRIBUTION TO VEGETATION TYPES

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PLANTS are probably the most important feature in the environment of mammals, as well as of all other terrestrial animals. All mammals are dependent directly or indirectly upon plants for food. Plants also furnish to many mammals shelter from the weather, sites for homes, nesting material and protection from enemies.

Some animals are limited for food to particular species of plants, or perhaps to a few closely related species. This is true notably of some insects. A few kinds of mammals also are stated to be restricted closely in diet. The South American sloth is said by Beebe[1] to feed entirely on the leaves of the cecropia, and the Australian koala is reported[2] to be almost restricted to the leaves of the eucalyptus. Most mammals, however, can utilize a considerable variety of food species. Nevertheless, considerable preference is usually shown by each herbivorous species for particular plant foods, and when overpopulation occurs certain plant species may be almost extirpated over wide areas. When the preferred foods are exhausted the mammal usually is able to continue to live in the region by turning to other less palatable food plants.

While mammals are not usually restricted to particular plant species for food, they often do show a fairly close restriction to certain general types of plant food. There is always some restriction in diet, of which the difference between browsing and grazing mammals is an example. Forest animals are likely to be best adapted to the plant foods found in the forest; and prairie animals are likely to prefer the grasses and other prairie plants. The food relations of mammals may be said then to be in general with vegetation types, rather than with particular species or taxonomic groups of plants.

For homes and protection, also, mammals are usually dependent upon types of vegetation rather than upon particular species of plants. To the squirrel, which during part of the year makes its home in hollow trees, it makes little difference which kind of tree furnishes the hollow, but it is obvious that deciduous trees will supply more suitable nesting places than will conifers. Accordingly,

[1] William Beebe, *Bull. N. Y. Zool. Soc.*, 26, 13, 1923.

[2] F. E. Beddard, Cambridge Nat. Hist., 10, 143, 1902.

the range of the eastern gray squirrel is found to be correlated in general with the distribution of deciduous forest.

A great many factors are involved in the control of the distributional ranges of mammals, but, of these factors, vegetation is usually most important. The various factors, including the vegetational factors as well as the physical factors, are very complexly interrelated, and the distributional range of any species of mammal is the resultant of the interaction of all the environmental factors.

The physical factors of importance in determining the distribution of terrestrial mammals may be listed as physiography, soil and climate.

Physiography controls mammalian distribution chiefly through the modification of climate. It is well known that elevated regions have in general colder climates than regions with lower altitudes. The higher elevations also usually have more rainfall and a higher humidity, increased cloudiness and a greater intensity of light. Slope exposure to sun and prevailing winds also modify the climate considerably, the sheltered slope being usually cooler and having less evaporation than the exposed slope. Soil drainage and character are modified to a considerable extent by the physiography.

The soil affects mammalian distribution directly to some extent, chiefly because the character of the soil determines the ease of burrowing. The kangaroo rats, for instance, are weak burrowers, and are found chiefly in sandy soil. On the contrary, the pikas are found almost exclusively on rock slides, where they make their homes under the rocks. If the soil surface is covered with rocks the feet of fast-running mammals must have some protection by pads or hoofs. Soil drainage is an important item for the mammals, for in soils poorly drained the burrowing animals may be drowned out in periods of heavy rainfall. However, the soil affects mammal distribution mostly indirectly, through its influence on the distribution of the plants. The ability of the soil to absorb and to retain moisture are extremely important as governing the growth of plants; so also is the chemical content of the soil solution.

Of the factors of the physical environment climate is probably most important for the life of terrestrial mammals. Climate not only directly limits the distribution of some species of mammals, but indirectly, through its influence on the growth of vegetation, it affects the distribution of all terrestrial animals. Among the climatic factors involved in the control of plant and animal distribution are the various features of temperature, precipitation, air humidity, wind movement, evaporation and light. For each of these factors the extremes must be considered as well as the seasonal and the annual means.

The various species of plants and of animals require different sorts of environments, and the conditions under which one species will thrive may be wholly unfavorable for the existence of another related species. Examples in plenty are evident when any tropical biota is compared with the biota of a region of temperate climate in the same continent, or if a desert fauna and flora are compared with those of a nearby more humid area.

It should be noted that species are limited in distribution by different degrees of the same factor as well as by different factors. One species of plant may be limited in its northward distribution by the length of the growing season; another species by the line where killing frosts occur in winter. An extreme temperature occurring only once in ten years might well prevent

the occurrence of a species in a region otherwise favorable for its existence. Further, all the climatic factors are interrelated, and a plant may be able to mature its seeds equally well in a region with short hot summers as in a region with long cool summers.

The animals, vertebrate and invertebrate, also constitute an important factor limiting the geographical distribution of animals and plants. The carnivorous species are of course dependent on the occurrence of their prey, and all species of animals must be in adjustment with the occurrence of their enemies and competitors. The incidence of diseases and parasites is also of much importance in controlling the distribution of both plants and animals.

The relationships between the various animals and plants of a region may be extremely complex. As already pointed out, some species of mammals are limited in distribution by the occurrence of their particular species of food plant or food plants, while most species are limited rather by the occurrence of vegetation types. The occurrence of some species of plants is prevented or their growth hindered by the presence of certain insects, and mammals also may seriously reduce the numbers of those plants preferred for food species. On the other hand, mammals may be beneficial to plants by eating injurious insects, by carnivorous mammals destroying herbivorous animals, and by the habits of some mammals which involve the transport or storage of seeds or vegetative parts of plants. Some of the species of animals and plants making up a biotic community will be affected adversely or favorably by the same grouping of environmental factors, others of the associated species will be controlled by quite other factor complexes. When we consider that the degree of abundance of every species affects more or less the existence of its food species, of its competitors, of its enemies and of its parasites, it is obvious that every species in an ecologic community is affected more or less directly by the activities of every other species. The physical factors of the environment are also directly involved, and any variation in an environmental factor affecting the prosperity of one species will affect ultimately and to some degree the whole community.

In this brief survey of the factors which limit the distribution of mammals and of plants it has been shown that plants limit the distribution of mammals in many ways, also that plants are limited in distribution by some of the same factors which limit the distribution of mammals. Although mammals are in general very adaptable, and although many forms range over several vegetation types, there is a considerable amount of correlation between mammalian distribution and types of vegetation.

In those cases where the occurrence of particular plant species does not directly or indirectly limit the distribution of mammals, the presence of certain plants might be considered to indicate conditions suitable for the presence of particular mammal communities. The use of plant species as indicators in this sense must, however, be applied with caution, because the habits of mammals apparently differ to some extent in different regions, and so also does the growth of plants. A mammal species closely limited in one region to occurrence in one plant community may not be so closely restricted throughout its whole range. Further, the plant indicators forming a major part of the normal environment at one location may appear elsewhere as scattered individuals, of little significance for mammalian distribution. In general the occurrence of vegetation and soil types are in my opinion better indices of

mammalian distribution than are particular plant species. However, it will be freely admitted that many vegetation types are characterized over wide areas by particular plant species.

Our knowledge of the paleontological history of the various animal groups leads us to believe that changes in the specific characters of animals and plants, similar to those occurring in the past, are still taking place. We feel sure that slow but certain changes in the structures and reactions of many species are occurring, leading to the production of new varieties and new adaptations. Each new improvement or change in the characters of one species will affect directly or indirectly all its associates. Adjustments and changes in the distributional ranges of all species must continually be in progress.

The reaction of the animal to the environment is fully as important as the character of the environment in enabling the animal to exist. The animal reaction is in itself a most complex affair, and involves organs of perception, conductors of nerve impulses, coordinating nervous centers, regulatory mechanisms, all the organs of the body, and hormones and other complex biochemical compounds, all in a state of constant adjustment to external and internal changes. The process by which an animal selects the proper habitat or secures for itself the proper food must be amazingly complex, and we have so far made only the slightest beginning in attempting to unravel all the tangled threads involved in these reactions.

The few critical studies which have been made of the factors involved in habitat selection by mammals indicate that the selection is in at least some cases not controlled entirely by the physical factors of the environment. Two species of deer-mouse, which have very different habitats in the upper Mississippi Valley, one occurring in the forest and the other in prairie, I have found able to live and thrive in the same laboratory and under exactly the same laboratory conditions.[3] In this case it is evident that the habitat limitations are not due to any difference of temperature, air humidity or wind movement between the prairie and forest habitats, because at certain times of the day or at certain seasons the factors may be identical in the two habitats. As a possible indication of the solution of the problem it should be pointed out that mammals have a highly complex nervous system and often show a great amount of associative memory. I find no difficulty in believing that the basis of habitat selection in this case is an inherited tendency to react in a definite manner toward the visual and other stimuli associated with forest and prairie, respectively. Habit is almost certainly involved also. We can be quite certain that the selection is not based on a simple tropism of any kind.

It is the practice of plant ecologists to divide the world into a number of regional climaxes. The climax is the kind of vegetation which ultimately would cover the region if fires, denudation and the other destructive forces of the environment were absent. Inasmuch as each ecologic climax community presumably represents an extensive and old vegetation type it is logical to assume that each climax should contain at least a few characteristic animal species. The climax vegetation type should be and probably is a center of evolution.

Every field naturalist is familiar with the fact that there are some types of mammalian adaptation, both of structure and of behavior, which are characteristic of particular vegetation types. The mammals dependent on the forests have types of adaptation differ-

[3] L. R. Dice, *Ecology*, 3, 47, 1922.

ent from those dependent upon the grassland, and tundra animals could not survive in a tropical desert.

In every regional climax are found, in addition to the climax vegetation type, a number of ecologic communities which are successional stages leading toward the climax. Some of the successional stages in any given region may be very different in vegetation type from the climax, and will, therefore, constitute a very different environment for the mammals. Some of these successional communities are of quite constant occurrence and some cover extensive areas. From the standpoint of mammalian distribution the successional communities may be almost as important as the climax community. Although only of presumably brief life on any one spot certain of these communities may always be present in the province and form therefore important places for evolution and adaptation.

On the contrary, the smaller subdivisions of ecologic communities, as they have been outlined by the plant ecologists, seem to have only slight significance in defining the limits of mammalian distribution. It has already been pointed out that mammals in general are quite adaptable as to food species, and individual animals may wander over considerable distances. It seems logical to believe, therefore, that in a mixed forest a difference in the particular tree species dominating a particular spot might make relatively little difference to the mammals. Thus, the various pure stands or consociations or alternes of the same forest may contain the same aggregate of mammals. However, where a dominant tree species indicates a difference in environmental conditions that consociation may shelter distinct mammal faunas. This, for instance, is true of the yellow pine and Douglas fir alternes found on the slopes of Pike's Peak, Colorado. The yellow pine forest grows on the exposed mountain slopes, and it lacks some of the mammal species found in the more moist Douglas fir forest of the sheltered slopes. These alternes would, however, be considered distinct associations by some ecologists.

The smaller divisions of ecologic communities should perhaps be different for each major group of animals. The factors limiting the occurrence of a snail or an insect are probably different in part from the factors which limit the range of a mammal. Certainly the special habitats of some insects, such as those that live under the bark of trees, mean little to a mammal. Perhaps the smaller subdivisions of ecologic communities should be different for different kinds of mammals. For all I know this may be true of some of the plants also, for the factors limiting the distribution of fungi and of small herbs would seem likely to be at least somewhat different from the factors of importance to the forest trees. It is true that the forest in major degree makes the habitats for many of its inhabitants, but while the height and density of the forest cover are important environmental factors for the mammals, the precise tree species involved are probably of little consequence, so long as the quantity of available food and shelter is the same.

Some species and groups of mammals range over several vegetation types, and individual animals may move freely back and forth between several plant communities. A cottontail rabbit, for instance, might travel in the course of a night through several minor types of deciduous forest, through a meadow, and into a blackberry patch. When we consider that a large mammal can and often does travel across a number of ecologic habitats within the space of a few minutes it seems useless to try to apply the minor ecologic subdivisions to these animals.

The mice and shrews and other small mammals have smaller individual ranges than do the larger species, and these smaller species are somewhat more restricted in habitat than are the larger forms. However, even the smaller species of mammals show little evidence of limitation to minor plant communities, but are in general related in distribution mostly to soil types or vegetation types.

Stratification or layering is sometimes conspicuous in mammalian communities. In a forest, for instance, the fossorial, ground-living and arboreal types of mammals may be quite distinct. However, the same individual animal may move frequently from one layer to another.

The best method of classifying the distribution both of vegetation and of mammals and other animals seems to me to be a division of the continents into biotic provinces, each of which is made up of several ecologic communities. At one time I called these districts biotic areas,[4] but Vestal's term of biotic province[5] has priority and is better. Each biotic province is characterized by its climax community, but the climax community of one biotic province often may be found as a minor or successional community in adjacent provinces. There are also communities which do not reach dominance in any biotic province, and some of these communities, such as the semi-aquatic communities, may have a wide distribution in several provinces.

The classification of the data of biogeography according to biotic provinces and ecologic communities will point out, I believe, the relationships which exist between the distribution of animals and plants, and also will show to some extent the relationships which both plants and animals have to climatic and physiographic provinces, soil types and the past history of each region.

[4] *Science*, n. s., 55, 335–338, 1922.
[5] *Amer. Nat.*, 48, 432, 1914.

BRIGHTER DAYS AHEAD

By RALPH E. DANFORTH
WEST BOYLSTON, MASSACHUSETTS

We often hear it stated that one twentieth of the world's population will be able to grow the food for the world. Perhaps machinery and methods will be such that less than one twentieth will be able to do it. Perfection of methods and machinery to do the work formerly done by many men and women will reduce the number of workers in manufacturing, commerce and salesmanship as well as in agriculture. What then will the great bulk of the population do? Will the above varieties of work be done by a few, or will the many divide it up, doing each a little of it daily, and having most of the day free for intellectual, artistic, musical and scientific activities, not to mention pure recreation?

The relations of labor and capital may seem like a different question but really it bears very directly upon the question above. It is doubtful that the workman will ever be content unless he (1) devotes part of his day to intellectual and esthetic pursuits, and (2) is not only a laborer but also partly a capitalist. When the workman is both capitalist and of the intelligentsia then the most serious problems between capital and labor will be solved. No real man or woman with active human brain will ever be satisfied to toil all day or most of the day as a wage earner working for others. He craves to devise his own life, think his own thoughts and fill his own place in the social world and the great world of outdoors.

Labor will not feel that it receives its full share of the earnings of industry however much of these it may be *given*. But if laborers labor but a few hours a day and live the higher life most of the day, exercising head and heart to the full, and enter into financial responsibilities they will feel that their labor is salubrious exercise without which they would not be as healthy or as happy, whereas their real life and much of their support came from other sources.

It is both humorous and pitiful to see a capitalist or other intellectual struggling to exercise his body enough to keep it trim and strong. How he toils at the setting-up exercises or in the gymnasium or on the golf-links when he can not take the time to go to the wilderness to hunt, fish or climb mountains. How eagerly he looks forward to a real expedition through less-known portions of the world! It would do him good to join the workers for a short time daily, and he would accomplish more, not less, of his intellectual work for doing it. Then would be established the true democracy of feeling which would break down the tension between the classes, yet never destroy the real difference between capable and incapable, wise man and fool. The individual would be forced to realize that it was his own fault or due to some insufficiency on his own part if he did not do as well as the other man.

Without any socialistic division of property the worker, working but a few hours a day, which would be all his share of the work needed by the world in which machinery and methods and power were doing most of the labor, would have most of his day free to use whatever mind and heart he possessed or could develop. He would have as good a chance as any one else to become a capitalist, a writer, an artist or musician.

The amount of capital invested in agriculture, manufacture, commerce and trade will perhaps increase as the required labor in the various fields of activity diminishes. There will be place for every laborer to invest what capital he can command. Thus capital rather than labor will increasingly direct the world's industry, while every truly intelligent laborer should be able to become, in part at least, a capitalist.

No human being is well rounded out unless he has developed what musical, artistic, literary, scientific and social capacities may be latent within him. He will not be happy or contented until he tries to do it. The short day and possibly the short wage, which may in future be unavoidable, may be the means of developing all those who are truly "worth their salt." If he is also a capitalist he will have no cause to complain, he will not suffer. His labor will bring in a part of his living and his other activities will bring in the rest. He will get his share of the other profits of industry because he will have bought diversified investments in industry. He will own as large a share of the capital of industry as he has the intelligence to secure honestly. He will not be prevented from doing this by being forced to labor long hours, in perhaps unhealthful circumstances, under the nervous strain of a mind not finding adequate outlet for its capabilities and under possibly undue physical strain.

Some one may ask right here how a person starting on part time could become a capitalist. One may reply that various individuals have started with nothing and become wealthy; that we do not expect the general public to become wealthy, but comfortable and happy; that individuals fit only to be coddled in a charitable institution could hardly expect to become capitalists or even independently comfortable and happy.

Far less than one twentieth of the world's population devotes time to scientific research, yet the number of those doing this research is rapidly increasing and the research workers are being increasingly well paid. As the demand for labor diminishes the demand for research will increase, so will the demand for literature of high grade and the demand for real art and music. Love of nature and the outdoor life in free sunshine, pure air, clean water to swim in, trees and parks and birds and mountains to enjoy, love for all these will increase.

The world has to-day many unfortunate individuals who should never have been born. No social or economic system can cure their fundamental troubles or give them their share of this world's goods. That would be asking too much of any plan for human betterment. Brighter days can exist for them only when they cease to exist. Perhaps a part of the scientific research may be directed to prevent such from being born into the world. Brighter days are ahead.

The present unemployment has been attributed variously to the world war, overproduction, tariff barriers, speculation, increased mechanization of industry and numerous other causes. The increased mechanization of industry will help to bring brighter days to the public in general, emancipating from drudgery, increasing leisure and adding to the general wealth of the world.

But the brightest days ahead are for the brightest people and the best. Pride of family will make those with the finest bodies and keenest minds and purest morals and noblest hearts increasingly careful to keep their families up to their high standards and even to improve thereon. The youth of such families, led both by family pride and by a selective love for the very best in man as in all else, will be able to "fall

in love" only with those most lovable and worthy to join their truly superior family circle. Here again scientific research will come to their aid, showing them more clearly what desirable and what undesirable traits are in the hereditary make-up of any likely person.

Brighter days are coming to all, but not to all equally, for all are not equal.

I can not believe, as some seem inclined, that war, sex and alcohol will always continue to be the great playthings of man. His brighter days and more fortunate circumstances will help him to become too intelligent to continue to consider any one of the three as playthings. Each will be relegated in time to its proper place, war to oblivion, sex to the production of better and ever better men, alcohol to strictly industrial uses. Drugs, including narcotics, will be more truly evaluated and used where, when and as they may confer the greatest real benefit.

The reign of common sense which should accompany the mechanization of industry will not eclipse the joys of living but increase them, both in number and quality. More and stronger joys will thrill the better life men will be living in the brighter days to come.

In the brighter days ahead, man's faith in his fellow man will increase because it will be better founded. There will be more reason to believe in your neighbor. You yourself will be more worthy of confidence.

THE WAYS OF THE ALLIGATOR

By Professor ALBERT M. REESE

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ONE who is known to be interested in the Crocodilia must be prepared to answer frequently the question: What is the difference between an alligator and a crocodile? While several distinctions may be given, it usually suffices to say that the snout of the alligator is wider and more rounded, and that the fourth mandibular tooth on each side fits into a corresponding pit in the upper jaw, while in the crocodile this enlarged tooth fits into a notch in its corresponding upper jaw. There are also differences in habits and temperament, as will be noted later. The genus Caiman is quite similar to the alligator and is often called alligator in the regions it inhabits.

Of the two species of alligator only the American will be discussed; the other form lives in China and the writer has no first-hand information concerning it.

It is possible that the word *alligator* is derived from *el lagarto*, the lizard, since it would have been very natural for the early Spanish settlers to call these similarly shaped animals lizards.

The American species, *Alligator mississippiensis*, is found in the South Atlantic and Gulf states from North Carolina to the Rio Grande. Kellogg reports isolated cases of alligators being found in New Jersey. The writer once investigated the report of an alligator living at Richwood, West Virginia. The animal, it seems, lived in the log pond of a saw mill at that place. It had been brought by a returning tourist from Florida and had been protected during the cold winters by an exhaust pipe from the mill that kept an area of warm water

FIG. 1. BUNGALOW OF THE TROPICAL RESEARCH STATION IN BRITISH GUIANA

FIG. 2. A TYPICAL SCENE IN THE OKEFINOKEE

in the pond in which it lived. It may be that the New Jersey alligators reached that unusual latitude in a similar way.

The alligator is quite sensitive to cold and in its natural habitat may pass the colder portion of the year in its cave or buried in the mud. In northern latitudes, even when kept in a fairly warm room, it will often lie more or less dormant and refuse all food for several months of the colder part of the year.

Being of amphibious habits it spends most of its time in or near water, but it may wander from pond to pond over considerable stretches of dry land.

If the accounts of early travelers are to be believed, the alligator was once to be found in incredible numbers in many of the southern watercourses. Bartram says:

> The rivers at this place from shore to shore, and perhaps near a half mile above and below me, appeared to be one solid bank of fish of

various kinds, pushing through the narrow pass of San Juans into the little lake on their return down the river, and the alligators were in such incredible numbers, and so close together from shore to shore, that it would have been easy to have walked across their heads, had the animals been harmless.

There were in those days, too, it was said, monsters measuring twenty feet or more in length. But the gun of the hide hunter and the rifle of the sportsman have changed all this, and no such numbers are now to be found and seldom is an animal seen that measures more than twelve feet.

It is not likely that the species will be entirely exterminated in the near future, since there are many inaccessible retreats in which it can hide and there are one or two preserves and numerous farms where, for one reason or another, the animal is protected. In some restricted sections the alligator is protected by law during certain seasons.

It is quite customary where a large alligator is on exhibition to tell visitors that the animal is "probably more than a hundred years old." It is likely that there is not the slightest foundation for this statement. Specimens have apparently lived in captivity for thirty or forty years. How any authentic information in regard to a wild specimen could be obtained is hard to imagine.

It was found in the Bronx Zoological Park that well-fed alligators grow at the rate of about one foot a year for the first ten years, after which the growth is slower, so that a fifteen-foot animal is probably much more than fifteen years old. Sexual maturity is probably attained in six or eight years.

The alligator, though apparently sluggish and awkward, is well adapted to its environment. Its rough, scaly back not only protects it against attack, but makes it highly inconspicuous as it lies quietly in the water or on a grassy bank (Fig. 4). As it floats or swims at the surface of the water, its eyes and nostrils are the only parts that project above the surface; by allowing something less than a foot for each inch between these two exposed spots the total length of the animal may be estimated.

When alarmed, the animal if in the water may sink quietly to the bottom, or if on the bank plunge in and thus escape. Parker found that the animal may remain submerged for more than five hours before drowning.

The tail, which is compressed and has a distinct fin along most of its dorsal side, is an excellent propeller that enables the animal to swim with sufficient speed easily to keep ahead of a rowboat

FIG. 3. A. M. NICHOLSON, A FLORIDA GUIDE

PICKING UP A DIAMOND RATTLER, A NEIGHBOR OF THE FLORIDA ALLIGATOR.

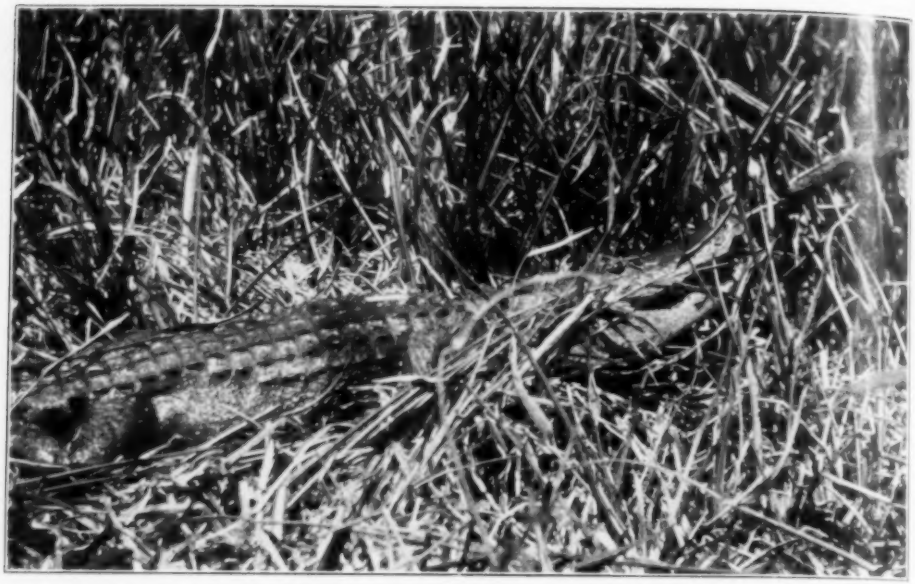


FIG. 4. AN EIGHT-FOOT ALLIGATOR
JUST DRAGGED FROM ITS HOLE.

FIG. 5. A GUIDE OF THE OKEFINOKEE SWAMP

or canoe. When swimming rapidly, the legs are held close against the sides of the animal so as to offer as little resistance to the water as possible. On land the tail may serve as a very effective weapon of offense or defense. Kellogg reports from Sweet "that a supposedly dead alligator nine or ten feet in length once snapped its tail against a man weighing two hundred pounds, breaking one of the victim's legs and throwing him several feet. The man was picked up unconscious." According to Ditmars the crocodile is more apt to act in this unpleasant manner than the alligator. He thus describes an experience of his own:

FIG. 6. "ALLIGATOR JOE"
A GUIDE OF THE EVERGLADES, IN HIS DUGOUT CANOE.

The writer well remembers his first acquaintance with a big fellow from Florida. Driven out of the crate the crocodile looked the picture of good nature. Standing away from what he thought to be the reach of his tail, the writer prodded the apparently sluggish brute with a stick to start it for the tank. Several things happened in quick order. With a crescentic twist of the body utterly beyond the power of an alligator, the brute dashed its tail at the writer, landing him such a powerful blow that he was lifted completely from the ground. As he left terra firma, an almost involuntary inclination caused him to hurl his body away from a pair of widely gaping, tooth-studded jaws swinging perilously near. Landing with a thud on one shoulder, though otherwise unhurt, the writer threw himself over and over, rolling from the dangerous brute that was actually pursuing him on the run, body raised high from the ground. For an instant it seemed as if the crocodile would win. As the writer sprang to his feet and glanced backward, he beheld the brute throw itself flat on its belly, open the jaws widely, then remain motionless as a statue. Such is the average crocodile—an active, vicious and, above all, treacherous brute.

Ditmars says again, in the same book:

When the keepers of the reptile house of the New York Zoological Park clean out the big pool of the crocodilians, they actually walk over the backs of some of the big gators, so tame are these. They never become unduly familiar with the crocodiles, finding it necessary to pen the latter behind heavily barred gates—and in

FIG. 7. INTERIOR OF THE MOUTH OF AN ALLIGATOR
SHOWING THE TRANSVERSE LINGUAL AND PALATAL FOLDS THAT SEPARATE THE FRONT REGION OF THE MOUTH FROM THE PHARYNX.

the process the men are often chased from the enclosure.

The tail is probably used also when the alligator seizes a large land animal and drags it under water to drown. This may be illustrated by feeding a tough piece of meat to two small alligators at the same time. As soon as the meat is seized each animal presses his legs close to his body and, by means of his tail, whirls over and over until the meat is twisted in two or one animal loses his grip on it. A large alligator by this means would be able to drown almost any ordinary land animal. Although so sluggish most of the time, the alligator is capable of almost lightning-like motions of its jaws in snapping sidewise at a moving object.

One of the curious ideas concerning Crocodilia is that it is the upper, not the lower jaw that moves. It is obvious that when an animal is lying with its head flat on the ground and opens its mouth the upper jaw must be lifted since the lower jaw can not be lowered.

To permit the alligator to hold a struggling animal in its jaws or to chew it, while submerged, without getting water into the trachea, it is provided with two folds of skin across the back of the mouth, one from the top of the base of the tongue, the other from the roof of the mouth (Fig. 7). When these folds of skin meet they form a water-tight partition that prevents water in the partly open mouth from entering the pharynx where the glottis, the opening of the windpipe, is located.

Unlike most of the class Reptilia, the alligator has a voice, and the strange bellowing of an old bull may be heard for perhaps a mile. Whether this voice be a call to females or a challenge to combat with other males is difficult to say. The young alligator makes a curious grunting noise that, with a little practice, is easily imitated, and it is custom-

ary for hunters to make this noise, with the idea of bringing the submerged adult animals to the surface where they may be shot. With its ear valves tightly closed and with several feet of water above it is difficult to imagine an alligator hearing this comparatively faint sound. As a matter of fact the writer never saw a hunter get any response to his grunting.

Even before emerging from the shell the alligator makes a sort of squeaking sound that may be heard for some yards; the use of this vocal effort will be mentioned later.

Captive alligators, even those of smallest size, often expand their bodies with air which is then expelled with a hissing sound that, in the case of a large animal, seems quite threatening.

Another characteristic, said to be more evident during the mating season, is musk, extruded from two pairs of glands, one pair under the skin of the lower jaw, the other pair opening into the cloaca.

The food of the alligator consists of practically any kind of animal matter, including its own kind, and even a certain amount of vegetable food may be consumed.

Kellogg has recently studied the feeding habits of the alligator, chiefly by examination of the stomach contents. He says: "The food of the alligator is made up chiefly of crustaceans (47 per cent.), fishes, turtles and other vertebrates (29 per cent.) and insects and spiders (23 per cent.)." It does not appear that they are seriously destructive of useful forms of wild life, as muskrats and turtles, and important food fishes do not bulk large in their diet. Their depredations on crabs and shrimps are not sufficient at present to cause fishermen any difficulty in meeting the market requirements. The insects they consume mostly are economically unimportant, and any influence they may have on the control of objectionable species of animals and plants is for the most part negligible. They undoubtedly are beneficial, how-

FIG. 8. "PROFESSOR" PYLE

A SOUTH AMERICAN GUIDE OF ETHIOPIAN EXTRACTION, AT THE EDGE OF A GATOR HOLE.

FIG. 9. PERONG
AN EAST-INDIAN GUIDE OF BRITISH GUIANA, IN HIS DUGOUT CANOE.

FIG. 10. ALLIGATOR HUNTERS OF THE OKEFINOKEE SWAMP

ever, in feeding upon the voracious alligator-gars, which destroy food fishes, and upon crawfishes, which are burrowing pests of agriculture.

In captivity the alligator will eat readily any kind of raw meat, including mice, rats or other animals of suitable size. To demonstrate "crocodile tears" it is only necessary to feed a hungry gator with a piece of meat just a little too large to be swallowed whole. While straining to gulp down the overlarge mouthful, tears will be squeezed from the animal's eyes in a very amusing way.

What the swallowing capacity of a huge alligator might be, it is difficult to say, but Ditmars thus describes the fate of a dog that approached too near a large specimen:

> As a dog, weighing about fifty pounds, unwarily approached the creature's tank, it was suddenly grasped and before completing its first yelp of terror was dragged beneath the surface. A few minutes later the twelve-foot saurian appeared at the top, holding the dead canine in its jaws. The dog was shifted about, amid the sound of breaking bones, and swallowed head first, and entire, after a few gulps.

The economic importance of the alligator is of course chiefly in connection with the use of its skin in making leather, though there is a considerable sale of young animals and of various alligator novelties to the tourist trade.

In 1902 the annual output from the tanneries of the United States was about 280,000 skins. During the past few years, according to Kellogg, the total number of hides taken in the United States would scarcely exceed 50,000 a year.

FIG. 11. JACKSON SLOUGH, FLORIDA

FROM THIS POND NUMEROUS ALLIGATOR TRAILS LED TO HOLES SUCH AS SHOWN IN FIG. 17.

In hunting alligators two methods are generally used. The more common way is to go after them at night, generally two men together in a small boat. The man in the stern propels the boat, either with a paddle or with a pushing pole. The man in the bow is provided with some sort of light, such as an acetylene

FIG. 12. A SOUTH AMERICAN GATOR POND
COVERED WITH VICTORIA REGIA LILY PADS

lamp like those that miners wear in their hats. This light causes the eyes of the alligator to shine in the dark so that they may be seen for many yards. The boat is paddled to within easy range and the whole top of the gator's head is blown off with a shot-gun. The dead animal is thrown upon the bank, to be collected and skinned the next day. A rifle may be used instead of a shotgun if the hunter be a sufficiently good shot to hit the eye of the gator.

It is commonly supposed that the animal is shot in the eye because the bullet will not penetrate the skull at any other place. This of course is absurd. But if the head of an alligator be examined, it will be found that a bullet entering the skull through the eye, especially from in front, is almost sure to go through the brain; a dozen holes might be shot through the skull in other regions without hitting the very small brain or causing a fatal wound. Another reason for shooting at the eye at night is that it is the only part of the animal that can be seen.

The other common method of capturing the alligator is to prod him, as he lies in his cave, with a long pole on the end of which a large hook is fastened; when he seizes the hook he is pulled out —not an easy undertaking if the animal be a fairly large one. It taxed the combined strength of the writer and a guide to the limit to drag an eight-foot gator from its hole.

The writer has never been in the alligator country during the mating season, but it is said that the bellowing, mentioned above, is much more frequent and that the air is often tainted with musk at this time. That there are also fierce combats waged seems likely from the

mutilated or missing appendages that are frequently noticed. After the mating season the nest is built and the eggs are laid.

In order to know when to get to Florida at a time the eggs were being laid, numerous return postals were addressed to "The Postmaster" at certain places located, so far as could be told by examination of a map, on streams and other bodies of water. These postals asked at what time of year alligators laid their eggs. According to the return cards, the laying season extended through practically the entire year. This illustrates how unreliable information may be though obtained from people who might be expected to know the facts.

It was later learned from Dr. S. F. Clark, who was a pioneer in the study of the Florida alligator, that the egg-laying season is in June. The first eggs were found on June 8; the latest to be laid were on June 26. In British Guiana, the cayman's egg-laying season was a few weeks earlier, but there was not so much difference as might be expected between localities at 7° and 25° north latitude.

On one expedition numerous nests were found, but none contained eggs. When the first rain came, to end a rather prolonged drought, every nest was found, the next morning, to contain eggs. It was evident that the female alligator was waiting for a rain to dampen the nest before she deposited her eggs in it.

It is supposed that the female alligator builds the nest, though there is probably no definite proof that the male does not do his share of the home building. As a matter of fact, the secondary sexual characters are so slightly developed, if at all, that it is practically impossible to distinguish the sexes by superficial appearance. At any rate, the nest consists of a rounded or conical pile of vegetable matter, the material of which depends

FIG. 13. A TYPICAL NEST OF THE FLORIDA ALLIGATOR

FIG. 14. A SMALL NEST OF THE CAYMAN
MADE ALMOST ENTIRELY OF GRASS AND EXPOSED TO THE FULL FORCE OF THE TROPICAL SUN

FIG. 15. AN ALLIGATOR'S NEST
OPENED TO SHOW THE IRREGULAR PILE OF EGGS

upon the character of the vegetation at the place where the nest is located. Fig. 14 shows a nest made almost entirely of saw-grass; Fig. 15 is a nest composed of flags and other similar plants; some cayman nests were made of fine débris scraped together into a mound; some crocodiles bury their eggs in sand. After piling up the material into a nest the animal apparently crawls over it, as indicated by the tracks, probably to make it more compact. The size of the nest varies from perhaps a small wheelbarrow load to a large cart load, and, as said above, it may be high and conical or very low and flat. After some weeks it may become so baked and hard on the surface that it can not well be torn open with the bare hands, and one nest was so compact that when the writer stood on it, thinking it was an old and unused one, only two or three of the forty-eight eggs contained in it were broken.

After the nest has been built, compacted and rained upon, the female opens a hole in the top and lays the eggs, with no noticeable arrangement, in the center of the mass of vegetation; she then covers them over so well that it is not possible without opening the nest or feeling in it (Fig. 15) to tell whether there are eggs in it or not. Often a nest that was torn open and found empty was covered over again by the alligator the next night, though she perhaps laid no eggs in it.

Many tales are told of the dangers of robbing an alligator's nest; so far as the writer's experience goes there is not a word of truth in these reports.

The nest is usually built on a slight elevation not far from the alligator's cave. It may be completely exposed to the sun or it may be in comparatively dense shade.

The number of eggs seems to bear no relation to the size of the nest. In a rather small nest forty-eight eggs were found, the largest number found in any one nest; in other nests less than a dozen eggs might be found; the average number per nest was about thirty. As many as sixty eggs have been reported from a single gator's nest, and one hundred eggs have been claimed for one crocodile's nest.

The eggs of the alligator vary considerably in size in different nests and somewhat in the same nest; the average diameters of a large number of eggs measured were approximately 73.5 mm and 42.5 mm.

FIG. 16. OVIDUCTS AND EGGS OF FLORIDA ALLIGATOR

The eggs are almost invariably perfect ellipses, not smaller at one end as in the case of the hen's egg. There is a thick, calcareous shell, rather rough in the alligator and in the cayman sometimes as rough as fairly coarse sandpaper. When first laid the shell is pure white, but it often becomes stained by the damp material of the nest.

An egg that has been incubating for some time may usually be recognized by a chalky band, perhaps a couple of centimeters wide, that extends around the center of the smaller circumference.

FIG. 17. A SMALL ALLIGATOR HOLE IN FLORIDA

This band is caused by a chalky deposit in the shell membranes, as may easily be seen by removal of the shell.

The yolk does not appreciably differ from that of birds' eggs, but the albumen, especially in the cayman, is distinctly green and of such thick consistency that the entire contents of the shell may be poured out into the hand without greatly changing its shape. One who has removed for study the blastoderm of a chick will remember that the operation is by no means easy; the removal of the alligator's blastoderm, if one be fortunate enough to find an unincubated egg, or even of an early embryo, is considerably more difficult.

The chief object in hunting alligators being to obtain their eggs for embryological research, it was of course important to obtain the eggs at the beginning of their incubation. Various empty nests were found and were visited several times a day, in the thought that if the eggs were obtained a few hours after being laid they would be practically undeveloped. Such, alas, was not the case, for newly laid eggs contained embryos of the stage of a thirty-six or forty-eight hour chick. Eggs removed from the oviducts of a just-killed alligator (Fig. 16) sometimes contained well-formed embryos and the few unincubated eggs that were thus obtained refused to develop, though apparently fertile. The only way that Voeltzkow was able to make the eggs of the Madagascar crocodile develop, in these beginning stages, was to remove them, at certain intervals, from the oviducts of a captive living animal. After the embryo is well formed, the egg may be transported indefinite distances without interrupting the course of incubation. On leaving South America some years ago the author packed two or three cay-

man eggs in a small basket of vegetation from the nest, and put them in his trunk. The trunk was not opened during the voyage of about two weeks, but when it was unpacked in Maryland, out crawled a baby cayman, perhaps the first of his kind to be born in a steamer trunk.

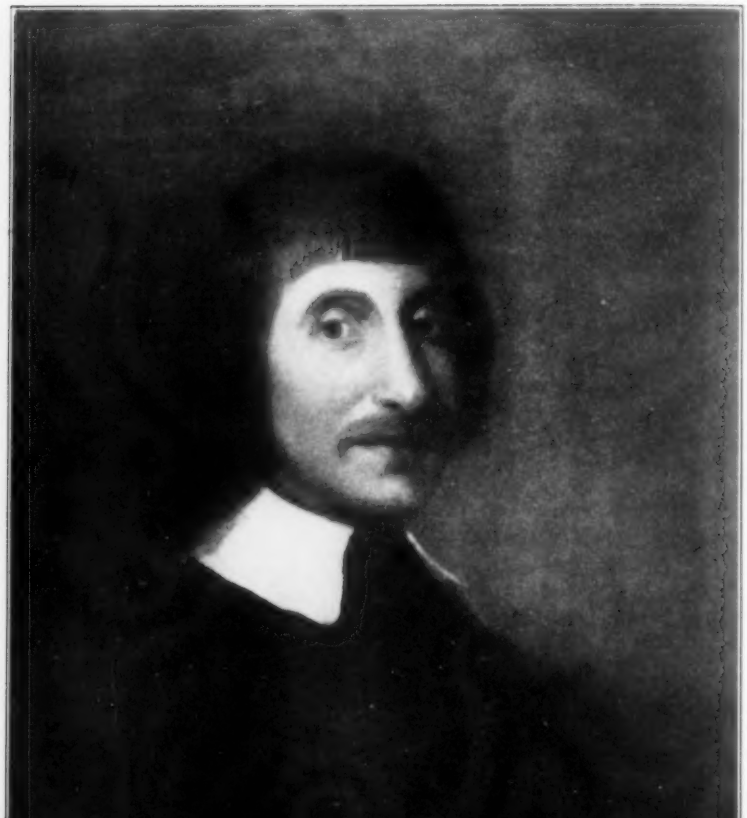
The alligator is about eight inches long when hatched, and it would seem perfectly impossible for so large an animal to have been contained in so small a shell, until one notices how much of the length of the new-born animal is in its tail and how compressed the tail is; it is a very snug fit at any rate.

It was formerly said that the heat of the sun caused the incubation of the alligator egg. Others now say it is the heat of decomposition of the green vegetable matter of which the nest is built that causes incubation. The writer is convinced for various reasons that neither of these ideas is correct. Many nests are built where they are exposed to the full strength of the sun all day; other nests, especially of the cayman, were found in the dense shade. When the hand is pushed into the center of a nest it feels distinctly cool during the heat of the day and distinctly warm during the night and early morning hours when the air temperature is possibly fifty degrees cooler than at mid-day. At all times the interior of the nest is moist. In other words, the compact mass of green vegetation simply serves to keep the egg moist and at a fairly even temperature. A "setting," if it may be so called, of alligator eggs continued the process of incubation in a perfectly normal way when packed in a box of wet sawdust that was kept in the sun in a Baltimore backyard during the day and was covered with blankets at night. The temperature of the interior of the mass of sawdust was found to stay fairly constantly at about 80° F. Alligator eggs were also incubated readily in an ordinary incubator at about 95° F.

It is an interesting illustration of the variability of living things that while the alligator egg develops in a moist nest and will probably die if allowed to dry, the Madagascar crocodile egg, which is almost exactly like the alligator egg, according to Voeltzkow, will mold and die if *not* kept dry.

The period of incubation of the egg of the Florida alligator is probably between eight and ten weeks and probably varies with the surrounding conditions.

As has been said, the young alligator may make a squeaking noise for some hours before leaving the shell, and it is supposed that the mother, whose cave is generally nearby, hears the cry of her new-born or about-to-be-born infant and comes to its rescue, otherwise it is hard to believe that it could dig its own way out of the compact and often sun-baked nest.



JOHN WINTHROP, JR.

THE ROYAL SOCIETY OF LONDON AND ITS INFLUENCE UPON SCIENTIFIC THOUGHT IN THE AMERICAN COLONIES[1]

By FREDERICK E. BRASCH

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THERE is nothing that has contributed so largely to the rapid progress which science has made since the Renaissance of learning in Western Europe as the growth of scientific societies and academies. To Italy, during the revival of learning, belongs the honor of being the first home of these modern organized academies, with the Accademia dei Lincei in Rome, founded in 1603. England was not slow in following the example of this enlightened spirit. Scientific truth was asserting itself in isolated places and by individual efforts through observations and experimentations contrary to the current tendencies in philosophy and religious dogma. Copernicus and Brahe led the way by observation, Galileo by experimentation, followed by Kepler and Descartes and Newton on mathematical analysis; Gilbert, Harvey and others, each in his turn laid the firm foundation of the value of empirical truths as derived from the phenomena of nature. In concentrated centers of learning of the early Renaissance, such as Oxford and Cambridge, the Aristotelian metaphysics of interpreting these phenomena predominated to the exclusion of the modern methods of experimentation or empirical truths. Scholasticism had prevailed so long that its firm hold in these centers of learning made it dangerous doctrine, if not possible heresy, to accept truths of nature derived by experiments and observational means. The basic principles of the current philosophy in England was that which was promulgated by two English philosophers, Bacon and Hobbs. What Bacon advanced was a method new to science, reasoning from particulars to higher generalities. Hobbs advanced what Bacon overlooked, namely, the deductive method. Both methods have their function in scientific progress.

It was this philosophy that led the early scholars of seventeenth century England to follow in the footsteps of the masters in the new method, namely, Copernicus, Galileo, etc. Therefore, the Royal Society of London was organized for the express purpose of advancing experimental knowledge and interpreting nature by seeking to establish some outside means to encourage direct contact with nature. It is, beyond dispute, the most honored of such institutions which has ever been founded. But it is to be remembered that the Royal Society was not called into being by direct royal decree of a sovereign power, as the Accademia dei Lincei and other later institutions, but by a spontaneous group of advanced independent scholars. Its foundation was laid during the time of Charles II, who was then in the midst of a civil war. Owing to the unusual conditions, men of little political thought, but of much scientific learning, found mutual association of exceeding great comfort and value. About the year 1645 several of these learned scholars, who resided in and about London, and who were interested in mathematics and physical sciences, agreed to meet once a week to discuss various problems and to exhibit such specimens of nature

[1] Due appreciation is here given to the American Council of Learned Societies for grants for aid in securing much of this material.

as they had acquired. These meetings were often held in the homes of the scholars, but for the most part at Gresham College, London. During 1648–1649 the meetings were held at Oxford. The interest in the experimental sciences grew rapidly as a reaction against the scholasticism of Oxford and Cambridge, and consequently the membership also grew. In London, in 1659, the meetings were held twice a week at Gresham College, where Mr. Robert Boyle lectured in chemistry, Mr. Christopher Wren on astronomy, Mr. Lawrence Rooke on geometry, and others in related fields. However, the meetings were disrupted for nearly a year, due to the short Civil War, and it was not until November, 1660, that the members were called together again at Gresham College. At this time the "Invincible College," as the group was then known, agreed to form and constitute themselves into a society. At first the membership was limited to fifty-five, but later it extended to properly qualified persons, with a president, secretary and a registrar elected out of their body. The following names stand out in the history of science as the early incorporators and original members: Sir Robert Moray, Henry Oldenburg, Robert Boyle, John Wilkins, Isaac Barrows, Seth Ward, Robert Hooke, Thomas Spratt, John Wallace, Christopher Wren and John Winthrop, Jr., besides some ninety others less well known. In 1662 (July 15th) a royal charter was obtained incorporating under the name of the Royal Society of London. The first meeting of the Royal Society was called at Gresham College by Lord Viscount Brouncker as president, with Dr. Wilkins and Mr. Oldenburg as the first secretaries. The early work and publications of the Royal Society are well known in the annals of the history of science. The *Transactions* and the *Proceedings* are recognized as standard authoritative scientific publications, and the membership to-day is an honored one, its awards being of the highest.

Previous to the founding of the Royal Society there was established in 1636, in the wilderness of the new colonies of Great Britain, in Massachusetts Bay Colony, a seminary of learning, known as New Cambridge, intended primarily for religious advancement. Many of its tutors were from Oxford and Cambridge Universities, and for the first fifty years its progress was of a slow but meritorious character—more was not to be expected under the trying conditions of the colonies' pioneer life. The early organizers were sagacious men, and accepted the trust laid upon them in its highest regard. New Cambridge later became known as Harvard College, and in its intellectual attainment could not rise higher than its source, as Oxford and Cambridge were yet in the throes of Aristotelian metaphysics and logic.

With Aristotelian philosophy constituting the principal phases of scholastic learning at Harvard College, we have also to bear in mind that other forces influenced the Puritanic philosophy, particularly Calvinism. Together with Aristotelian metaphysics, intellectual progress was apparently confined within a circle. The substance of Calvinistic metaphysics is a form of natural theology, containing all the elements of lost hope for further spiritualistic and intellectual development. A full treatment of Aristotle's metaphysics and Calvinistic theology will be reserved for later consideration; suffice to say that a gradual change finally became possible. This change came in part with the introduction of Descartes' "Logic" by William Brattle, tutor of the college. Most significant, we note the liberal tendency in instruction at Harvard following this date (1724) by one who, contrary to general historical interpretation, was quite liberal and progres-

sive, namely, Cotton Mather, who said, "It is a subject of gratification to me, that you who have been initiated in liberal studies, have adopted a liberal mode of philosophizing, instead of floating about from school to school as if you were literally peripatetica. I doubt not that the Essays of Gassandi[2] are familiar to you; in which he demonstrated that many of Aristotle's positions are deficient—others carried to extreme, others still fallacious. . . ." Again, Mather lays down the principle that the master of arts candidate should be examined more fully concerning astronomy, geometry and natural philosophy. In astronomy, the systems of Ptolemy, Brahe and Copernicus were taught, but the doctrine of Copernicus regarding the universe was finally accepted.

It was not, however, until the new spirit of the academies of science then existing influenced the entire mental attitude of the thoughtful scholars with the new experimental philosophy that progress was made. The Royal Society paved the way in this new humanism for Oxford and Cambridge, and, in turn, for the new school in the colonies.

How far this new spirit of the Royal Society's influence was exerted can be seen by first noting the list of those who in the colony have been honored by the society, and who in turn contributed to the progress of learning and the society's welfare. Massachusetts Bay Colony was represented by nine fellows of the Royal Society: Connecticut by one; Pennsylvania by three; Virginia by three; Rhode Island by one; and the Carolinas by one. In describing their contributions to science and to the Royal Society, each fellow will be considered in the order of the date of his election. The contributions of each of these famous scholars are of a pioneer character, and thus from our present point of view rather crude and childish—yet, how else can a beginning be made? Even thus their own work was accepted as of material value by their great contemporaries, namely, Linnaeus, Woodward, Newton and Halley, Collinson, Flamstead and others.

John Winthrop, Jr., oldest son of the first governor of Massachusetts, had the great honor of being the first colonist elected fellow, in 1663, while he was residing in London temporarily. He was recognized as a man of great learning and therefore assumed responsibility in the local government of which his father was the head. Winthrop settled first in Ipswich and later in the Connecticut colony. In 1634 he was elected governor and continued in this capacity with one or two short exceptions, for the rest of his life. He was educated for the law, but, no doubt, mastered as much of the sciences as was then known, and through his travels and contact with scholars on the continent, he was well prepared to assume leadership in his new home. When he arrived in the colony, his most valuable possessions consisted largely of books, and each year this collection was supplemented by new accessions. From a personal study of the contents of this remarkable collection, as well as from an admirable account recently published[3] it is clear how Winthrop, Jr., became so well versed in the subjects in which he displayed his talent and made his advancement. He is generally credited with being the first chemist and metallurgist in the American colonies, and this, we note, was supplemented with a knowledge of alchemy. Again, he is credited with being one of our earliest medical scholars—a follower of the schools of

[2] "Institutio astronomica, juxta hypotheseis tam veterum, quam copernici et tychonis," Parisiis, 1645. This little book was virtually the first scientific treatise used at Harvard College.

[3] C. A. Browne, "Scientific Notes from the Books and Letters of John Winthrop, Jr.," *Isis*, 11: 325–342, 1928.

both Galen and Paracelsus. It is but natural that his interest in chemistry and medicine should have correlated so well, for the practice of each depended upon a knowledge of the other. His discoveries of chemical substance in plants and metals revealed a thorough understanding of the sciences as they were then known. Again, his practical knowledge of chemistry gave him many opportunities to develop mining and engineering industries for the economic progress of the colony and of the mother country, and evidence of his skill is still to be seen in parts of Connecticut. These various engineering developments led to his promoting the pursuit of iron melting and foundry business about 1642. He also promoted many chemical industries, for we note that in 1648 Winthrop was granted a commission by the court of Massachusetts to manufacture salt and saltpeter. Later, in 1651, in Connecticut, he was granted a monopoly for working lead, copper, tin, antimony, vitriol, alum, and other like industries.

It is therefore not surprising that a man so well known in the art of chemical preparation should have been called upon to extend his usefulness. Records are preserved through letters, wherein extraordinary treatments of the principal chemical remedies which he used for his medical practice are mentioned. The use of saltpeter, tartar, copper, white vitriol, sulphur, iron, rosin, balsam, sassafras were prescribed with other simple Galenist methods. The medical learning of Europe at that time had its source from two schools of practice, namely; the followers of Galen were versed in the use of herbs and plants, etc., and were known as botanical doctors or Galenists; those who were studying the use of mineral properties for patients were called chemical doctors, or followers of Paracelsus. Winthrop's natural liking for medicine seems to have been of long standing. Whether he studied this at Dublin or secured some knowledge of it from his ancestors is not known. However, his first patient was his father, and his service thereafter was called for by Puritans, Quakers, Indians and the Freemen of Rhode Island. Poor and rich alike were treated without fee or reward. He prescribed by letter and personal visits and in each case he sent his affection and godly blessings, showing him to be a man of great human understanding. His preparations and advice for fevers, colds, wounds, poisonous bites, stomach troubles and many other well-known ailments of the colonists form the earliest chapters of the history of medicine in the United States.

When we consider Winthrop as one of the first physicians and chemists, it must be remembered that his official duties as chief executive of the Connecticut colony at Hartford and New London were also demanding time of first importance. The records preserved in his letters and notebooks, as well as a large collection of treatises on chemistry and alchemy, indicated that Winthrop, Jr., was well educated for the pursuit of these interests. Many of his books were from the famous scholars of his period, and his chemical library alone at that time consisted of fifty-two volumes. His papers, letters and library, still extant, form the earliest scientific record and library in the history of science in the United States. These are to be found in the Massachusetts Historical Society library and the New York Society library.

In 1661 Winthrop, Jr., visited England for the third time, and on this occasion it was for the express purpose of securing a royal charter for Connecticut colonial government. This he secured from Charles II as a result of his great influence at home and abroad,

which is attested to by his wide correspondence. This mission afforded the rare opportunity at an eventful period in the history of the Royal Society of furthering Winthrop's scientific inclinations, and renewing old scientific acquaintances, as well as making new friends of learning. The society having reestablished itself after a short period of retirement due to a civil war in November, 1660, Winthrop's visit, therefore, was a great satisfaction to the company of scholars anxious to hear of new things from the new world. He was proposed for membership in December, 1661, at a meeting held at Gresham College. The charter for the society was secured in July, 1662, and therefore Winthrop's visit came in the period of reorganization, and he was elected as one of the original fellows on May 20, 1663. On his return to the colony he became the western correspondent for the society, having on his list of correspondents some of the most famous names of the seventeenth century, namely, J. Hevelius, J. Kepler, Sir Robert Moray, Sir Isaac Newton, Sir Christopher Wren, Robert Hooke, Sir Robert Boyle, John Dee, I. Barrows, and many other lesser known scholars. The society having now become firmly established, Winthrop continued to send specimens of such nature as would be of interest to the scholars for topics of discussion, and which later enriched the museum, namely, minerals, plants and "diverse curiosities of nature."

Probably Winthrop's most famous contribution to science and the most unique observation of a natural phenomenon to be found in the annals of astronomy is his supposed discovery of the "fifth satellite of Jupiter." This most interesting record which he sent to the secretary of the Royal Society not alone attests to the colonial scholar's great ability, but his profound understanding of the problems of astronomy as well. We find in a letter[4] addressed to Sir Robert Morey the following account of the fifth satellite of Jupiter. The historical interest surrounding this famous satellite makes it worthy of giving the original account as was written by Winthrop to Morey:

Hartford, Jan: 27: 1664/65

Honorable S.r—In my former I gave your hon.r an account of the favor I had of your letter by the Hon.ble Colonell Richard Nicolls. I then omitted to acquaint your honor what now I will be bold to add; that havinge looked upon Jupiter w.th a Telescope, upon the 6.th of August, I saw 5 (?) Satellites very distinctly about that Planet: I observed it w.th the best curiosity I could, taking very distinct notice of y.e nūber of them, by severall aspects w.th some convenient tyme of intermission; & though I was not w.thout some consideration whether that fifth might not be some fixt star w.th w.ch Jupiter might at that tyme be in neare coniunction, yet that consideration made me the more carefully to take notice whether I could discerne any such differenece of one of them frō the other foure, y.t might by the more twinckling light of it or any other appearance give ground to believe y.t it might be a fixed starr, but I could discerne nothing of that nature: & I consider that the tube w.th w.ch I looked upon them though so good as to shew very clearely the Satellytes, yet was but of 3 foote & halfe w.th a concave ey-glasse; & I question whether by a farre better tube a fixt star can be discerned so near the body of that planet when in the ever bright activity of its light, for, if so, why are there not often if not alwayes seene w.th the best tubes the like or more. Is not Jupiter often in neere coniunction w.th them, expecially *in via lactea*? I have been much in doubt whether I should mention this, w.ch would possibly be taken frō a single affirmation but a mistaken novelty: but I thought I would rather beare such censure than omitt the notice of it to such worthy friends as might frō the hint of it take occasion to cause more frequent observations to be made upon that planet, & at least this will at length be cleared, whether the light of Jupiter doth not take away the appearance of fixed starrs so neere in coniunction w.th it, as that they should appear w.thin the periphery of that single *intuitus* by a tube w.ch taketh in the body of Jupter & that at the same unmoved aspect: & I am bold the rather to mention this

[4] Massachusetts Historical Society, *Proc.*, 16: 220–221, 1878.

as an inquiry whether any such nūber of Satellites or moons hath beene seene by your hon.r or Mr. Rooke or any mathematicians or other gentlement y.t have good tubes & often have the curiosity to view y.t planet, for possibly it may be new to me w.ch hath beene more usually knowne by others, though the notion of such a thinge is not new to my selfe, for I remember I mett w.th the like narration many years since in a little booke intituled Philosophia Naturalis Joh. Phociliden, though then I thought that twas but a mistake of some fixed starrs.

Of course, at first it is impossible to attach any great importance to this observation. We assume, as Winthrop rightly does, that this apparent fifth satellite must have been a faint star in close juxtaposition to other satellites in the field of view of the telescope he had. This was a 3½ foot focal length refractor, with a concave eye glass, which he probably secured along with chemical apparatus during his travels in Europe. However, the following interesting and important historical data are to be deducted from this unique discovery. First, Winthrop is to be credited with being a cautious and keen observer of natural phenomena. He does not ask to have the letter inserted in the *Transactions* of the Royal Society but first requests others possessing more powerful telescopes to verify his observation. This he does by requesting Lawrence Rooke, professor of astronomy at Gresham College and a well-known observer of Jupiter and its satellites, to verify his observations and apparently with no results, as nothing remains extant concerning this fact. Also, in October, 1670, he writes from Boston to Dr. Benjamin Worsley for information concerning this satellite. Again in 1671 after presenting his telescope to Harvard College, he requests his son, then a student, to learn if this satellite had been observed. Second, the fact remains that this object was suspected fifty years after the great discovery made by Galileo, and systematic observations were made in the American colonies. Third, Harvard College possessed the first known telescope in the colonies, which was probably lost in the burning of Harvard Hall in 1764.

Some few years before the late Dr. E. E. Barnard (the discoverer of the fifth satellite) died this account was shown to him, and in reply his remarks are as follows:

Thank you for sending me the magazine and newspaper cuttings about Winthrop and the fifth satellite of Jupiter. I saw this article a good many years ago. It seems to me it hits pretty hard at Wm. Herschel and Lord Rosse and others with powerful telescopes that are nearer to Winthrop's time! I suppose they never looked at Jupiter. It makes me feel specially humiliated just now, for I have only caught the feeblest glimpses of the fifth satellite with the 40-inch during the past two years. Winthrop's telescope must have been specially good for him to have seen this faint object with his imperfect instrument in 1664. I am comforted, however, by the fact that Dean Swift in "Gulliver's Travels" made the Lilliputians discover the two little moons of Mars such a long time before Hall found them with the 26-inch at Washington. The satellite of Venus was also a product of the early telescopes.

Winthrop's interests extended further than his interest in Jupiter, for in a letter, dated March 18, 1671/72, received from Oldenburg, former secretary of the Royal Society, we note that Winthrop was asked if he had observed a new comet seen by Hevelius on March 6 in the constellation of Orion. Also a new star found in *sub capita* Cygni which was first observed last year (1670) and is again visible.

The large correspondence of Winthrop was the great means of receiving fresh scientific news of events from Europe, supplemented, of course, by the *Transactions* of the Royal Society. There are in many cases no replies extant, showing what response he made to the various suggestions, as more often than not these documents and various specimens of nature, etc., were lost by the frequent shipwrecks of those days.

John Winthrop, Jr., F.R.S., administrator, industrialist, chemist, physician and general student of nature, died in Boston, April 5, 1676, and lies buried in King's Chapel in the same tomb with his illustrious father.

Roger Williams, a friend and an associate of John Winthrop, Jr., and a pioneer religious leader in the colonies as well, was also one of the original members of the Royal Society, having been elected in 1663. There is no record that he complied with the paramount regulation of the society which required the members to sign the roll personally in London, but his name appears on the honored list.

Williams was born in London in 1604, and attended Pembroke College, Cambridge, and was graduated in 1626, and took orders in 1629. The following year he embarked for the colonies, landing at Nantasket. On his arrival in the new land he became minister and teacher, but due to his vigorous and independent views concerning church and state his presence soon became obnoxious to the general community and to the theocratic authorities in particular. His courageous views forced him to establish a separate state of existence, and thus became the founder of Rhode Island. All Williams' life was concerned with education, politics and religion. A careful study of Williams' life reveals no contribution of a scientific nature which would account for his election to the Royal Society unless it was on the ground that he published a philological study entitled "A Key into the Language of America, or an help to the Language of the Natives in that part of America called New England" (London, 1643). It is well to note, however, that twenty years elapsed between the publication of this work and his election to the society in 1663. The majority of his writings were upon "soul liberties and wide religious toleration." Williams' prime contention was that the civil powers should have no authority whatever over the conscience of men. How far reaching this doctrine became is clearly seen in the history and development of the church in this country, and in the political form of our civil government.

Williams' ideas made but little impression on the orthodox puritanism of the time for the reason that New England was too narrow in its views, but it remained for the organized body of the liberals, such as the founders of the Royal Society, to take cognizance of the young rationalist in the colony.

The doctrine of the theocratic form of government, held by the Calvinists and embodying the divine right of kings, was overthrown by an absolute decree which finally made possible and established an uncontrolled sovereignty in the will of man. Colonists in the middle of the eighteenth century began to feel the force of Williams' philosophy of liberal and rational thinking. John Milton spoke of Williams as an extraordinary man and a noble confessor of religious liberty, who sought and founded a safe refuge for the sacred ark of conscience. Williams became first governor of Rhode Island, which office he held for three years, 1654–1657.

He was probably the best linguist the colonies possessed (John Eliot was the first, but not a fellow of the R.S.) which probably accounts for his frequent contact with Milton when he made a visit to London in 1643. Williams' life came to an end near the place which he had first founded in Providence, in April, 1683.

In considering our third colonial scholar from the point of order of election to the Royal Society, there seems to be some doubt or confusion of persons to this claim, between two brothers. Of Thomas and William Brattle, their respective claims to fame rest upon evi-

dence favoring the former. Thomas Brattle was born in Boston in 1658 and graduated from Harvard College as master of science in 1676. He became a successful merchant and later treasurer of Harvard College, which post he continued for twenty years. Due to his wealth and natural inclination he chose to devote much of his time to scientific pursuit, especially in the studies of mathematics and astronomy, excelling in the former. As evidence of his proficiency in mathematics and astronomy, he prepared "An Almanack of Coelestial Motions of the Sun and Planets with their Principal Aspects for the year 1678," published in Cambridge in 1678. Many of these almanacs at that time were prepared and accepted by the college authority for advanced work, on which the master of science degree was given. In this case it is very evident that Brattle prepared his dissertation by computing the elements necessary for solar and planetary data. These little booklets, which are now extremely rare, show a surprising amount of worth-while astronomical information (and at times some astrological) possessed by the colonists' intellectual class. These almanacs contained also much practical information, such as giving the time of the rising and setting of the sun and moon, guiding the scholar and mariner, and locating the planets and stars in conjunction and opposition, giving longitude and latitude. Eclipses of the sun and moon were predicted successfully, and meteorological and historical data were to be found in abundance. In many cases, on the final or concluding pages of these almanacs, the author essayed to give some phases of the history of astronomy or why the Copernicus system should be adopted, or how eclipses occur, etc.

Brattle has the greatest distinction of being the first observer in the American colonies who was of eminent practical service to the great Sir Isaac Newton. It is recorded that his observations on the comet of 1680 (later known as Halley's comet) were furnished to the Royal Observatory at Greenwich. The five or six observations of position on this comet furnished to Halley, then director, and Newton, were of such importance as to time and position that they were used by him in making the first cometary computation thus far made, according to Newton's theory. Crude as these observations for position and time were, they were accepted, however, and through the skilful hands of Halley and Newton were used to excellent results. True, these observations were not made according to the standard astronomical requirements, namely, true time and observed longitude to within a second of time. For instance, using Newton's words, he said: "I was informed by Dr. Halley that on the same day (November 18, 1680) at Boston in New England, in the latitude of $42\frac{1}{2}°$ at 5 hr. in the morning (that is 9 hr. 44 min. in the morning in London) a comet was seen near $\simeq$ 14° with latitude 1° 30′ south.[5] In all about six sets of such observations were furnished to the Royal Observatory. He next observed a solar eclipse on June 12, 1694, his account being published completely in the *Transactions* of the society,[6] which in part reads as follows:

> On the 12th of June, 1694, in the morning I went to the Colledge at Cambridge, about 4 miles from Boston, and observed, with the Brass Quadrant there, with Tellescopick Sights, the Rays of the Sun being transmitted through one of the said Sights, on a clean Paper, pasted on a plain Piece of Board, and fastened at right angles at about a foot distance from the said Sight, on which Paper I had drawn a Circle between 2 and 3 Inches Diameter equal to the Suns disk, and within that several Concentrick Circles dividing the Diameter into 24

[5] Newton's "Principia." American edition by Chittenden. New York, 1848, pp. 481–84.

[6] *Phil. Trans.*, R. S., 24: 1630–38, 1704.

equal parts, whereby I could observe to 1/2 a digit, the room in which the observation was made was darkened with Blankets, and in order to render the Observation the more Exact (Mr. Henry Newman assisting me all the while) I took the Altitude of the Sun with the aforesaid Quadrant, as followeth.

Observations made of the Suns Altitude before the Eclipse began, in order to rectifie the Watch.

This was not a total eclipse of the sun, for he states that the beginning and end of the eclipse were only 10½ digits where covered by the moon. He observed this phenomenon with care and much preparation, for the problem was of great importance, namely, the determining of the exact longitude of Boston. A comparison of observations with those made in London placed Boston in longitude $4^h\ 43^m$ or 70° 45′ west of London, and the latitude assumed in the calculation was 42° 25′. The unsettled problem of determining the exact longitude was then uppermost before the Greenwich observers to master, mainly due to England's growing maritime power. Further details concerning this eclipse are not necessary here. Another eclipse of the sun was observed by Brattle on November 27, 1703:

when at half an hour past 8 in the morning, I set my Clock exactly by my Ring-Dial, and at half an hour past 9 they nicely agreed, etc.

And he adds:

I observ'd this Eclipse with a Telescope of one joynt, 4 foot and a half in length, and had only 2 glasses, so that it inverted the object: and I had a red Glass which suited it, so that I could screw it in just before the Eye-Glass, and was not fain to hold it in my hand, as when I observ'd the Sun's altitude with the brass Quadrant, which was a great convenience.

The next astronomical work of Brattle was the observance of three lunar eclipses, the first observed on February 11, 1700, the second on December 12, 1703, and the third on April 5, 1707. The facts concerning these eclipses are so simple that no mention will be made as to time and position relative to them. Science is also indebted to him for the earliest precise observation known to have been made on the variation of the magnetic needle, which he found to be, in 1708, about 9° west of north. This observation proves that the needle, which in 1782 varied less than 7° from true north, but which since that time has been moving westward until it is now more than 9° west of north, has returned to the position which it held about 200 years before, and therefore that the change is periodical.

About 1689 Brattle visited London and between that year and 1692 he was presumably elected fellow of the Royal Society of London. There is no evidence of his election in the records of the Royal Society except that of his younger brother William in 1713. The question is whether or not there may have been a misprint or omission during the days of uncertain printers or proofreaders, or, possibly secretaries. Our best proof is to be found in a manuscript letter[7] giving a full account of the delusion of witchcraft in Salem, dated October 8, 1692, signed as Thomas Brattle, F.R.S. However, history may state that he is reputed to have been elected. Brattle proved himself a worthy candidate for this honor and must have been recognized by his friend, then secretary of the Royal Society, J. Hodgson, whereas his brother William had no claim or contribution to offer in return for the honor which posterity has ascribed to him. William Brattle was a tutor at Harvard College and published a celestial almanac for 1682. Brattle was practically the first tutor in philosophy in the American colonies, and is credited with having published the first book on logic in the colonies. This book on logic was merely a reissue in part of Descartes'

[7] Mass. Hist. Soc., *Collection*, 5: 61–79, 1816.

"Compendium Logicae." Descartes' philosophy had become so deeply rooted in Harvard that in 1690 a thesis was maintained in the affirmative by a candidate for the degree of Master of Arts, with the title, "Is doubt the beginning of all indubitable philosophy?," which signifies a characteristic Cartesian philosophical attitude. Brattle's work was used for more than half a century. This was in sharp contrast with Aristotelian and scholastic philosophy taught for the first half century. The new philosophy of Descartes was later reinforced by the great English scholar Locke on "Human Understanding." Thus it will be seen that William Brattle was the founder of the modern philosophical school, established in Harvard in 1690. This may have been sufficient claim for recognition of the Royal Society to accord the honor of fellow to William Brattle. At this late date it is not our purpose to lay open the question of prior right, but evidences are sufficient to show that the Royal Society of London recognized our scholars for their efforts and gave them encouragement and sustained their records in some form of incomplete honors. This was also very evident when we find that our next fellow, John Leverett, from the colonies was elected at the same time as his classmate, William Brattle, for his accomplishments as the eighth president of Harvard College, from 1704–1724.

Thomas died in 1713, and William in 1717, and both lie buried in King's Chapel, Boston.

Between the period in which the two Brattles are reputed to have been elected fellows to the society, came a man of considerable note and ability, both in scholarship and administrative influence. William Byrd II was born on March 28, 1674, in the colony of Virginia, and was educated in England. His election as a fellow of the Royal Society occurred in 1696 at the very early age of twenty-two years, which action took place after he had been called home on account of the death of his father. At this time he brought back with him the beginning of one of the finest private libraries known in the colony. This library was composed of approximately 4,000 volumes of the best literature of the period, and until recent times was kept intact. Although his career was not of a scientific nature, his great influence and encouragement gave the needed impetus to others who were engaged in pioneer scientific work. He was in constant correspondence with Sir Hans Sloane,[8] secretary of the Royal Society from 1693 to 1712, and president from 1727 to 1741 (elected president following the death of Sir Isaac Newton). These letters have much to say concerning the native plants and minerals of Virginia, and emphasize their experimental, as well as their economic uses and their medical properties. His relations with the Royal Society were most cordial, and he constantly endeavored to promote the influence of the society in the colony. In a communication he urged strongly that the society send over properly prepared botanists or natural philosophers to explore the wonderful plant and animal life of Virginia instead of accepting the reports of discarded ship's doctors who knew little of the curative properties of plants, and who were incapable of making great discoveries.

As Byrd had little or no scientific training, he made no attempt in the experimental studies, but forwarded his plants, their roots and seeds, to Sir Hans Sloane, who in turn described and classified their parts and medical properties. In his letters he described his meetings with Dr. John Tennant and Mark Catesby and other wandering botanists in search of plants and minerals,

[8] Sir Hans Sloane was a distinguished botanist of England, and his great collection of books, manuscripts and specimens laid the foundation of the British Museum in 1753.

from whom he secured new information of scientific value.

Byrd published only one paper in the *Transactions* of the society, and in this he gives his observations of coloration upon a Negro body. His paper was entitled "An Account of a Negro-Boy that is dappel'd in several Places of his Body with White Spots."[9] His later writings, published in 1841, and known as "The Westover Manuscripts," were not brought out until three years before his death. "The Westover Manuscripts" were composed of: (a) "The History of the Dividing Line Between Virginia and North Carolina," (b) "A Journey to the Land of Eden," (c) "Progress to the Mines." The first paper is a report of a commission, of which Byrd was a member, which was appointed in 1728 by His Majesty to prepare and survey a boundary line between Virginia and North Carolina running through the Dismal Swamp. This was apparently the first attempt to accurately determine a boundary line between the colonies or states. Later a revised survey was made, and Byrd called his report "The Secret History of the Line." In the second and third papers he gives an account of the opening of iron mines and the inspection and progress of mines in operation. These papers do not possess great scientific value, much less a description of the land he visited, but merely describe in detail the state of civilization on the frontier. They are interesting, however, from a literary point of view.

One of Byrd's most important activities during his life was the endeavor to further colonization in the colonies, and this is brought out in his correspondence with John Bartram, botanist, of Philadelphia, and other influential men in the colonies, for he foresaw the great economic and social importance of the colonies to England. Byrd contributed also largely to the economic progress of the colonies by his large land holdings, the importation of slaves, sugar, ginger and other commodities for the comfort of colonial life. He also greatly advanced the intellectual life of the colony by encouraging the study of all phases of natural phenomena, the importation of scientific instruments, books, pictures and music, and was recognized as a man of great power and authority. Byrd died at Westover on the James River (one of the most famous of Virginia plantations) on December 4, 1744, and lies buried on his estate which he loved so well.

John Leverett was born in Boston, Massachusetts, on August 25, 1662, and was educated at Harvard College, from which he graduated in 1680. He also became tutor of the college, but due to his active interest in law he later practiced in the courts of Massachusetts with much success before he was elected president of Harvard College. Leverett was a liberal, forceful in his views on religion and education, and was a man of exceptional ability and scholarship, and therefore showed excellent and wise leadership during his period of administration at Harvard. What reason the Royal Society had for conferring in 1713 a fellowship on Leverett is not known, except possibly for his high standard both as a leader at the bar and in scholarship and administrative power. This seems somewhat unusual at that time, since Leverett had made no particular contribution to science in the colonies. The fact remains that he was recognized as a distinguished citizen and an honor to Harvard College.

Cotton Mather, the celebrated minister and writer of Massachusetts, according to printed records became our sixth scholar in the young colony to be recognized by the Royal Society. His election as fellow took place in 1713, the same year that Thomas and William

[9] *Phil. Trans.*, R. S., 19: 781, 1697.

Brattle and Leverett were reputed to have been elected. Mather was born in Boston, February 12, 1663, and graduated from Harvard College in 1678, when scarcely fifteen years of age. He became mostly interested in theology, but probably is best remembered in literary history as the first historian of Harvard College. This early history is the most complete account of the founding and the first years of the college. This account appeared in his "Magnalia" which was published in London in 1702. Mather was considered the most learned man of his period, and while educated not as a scientist, to be sure (no set discipline was then known for a career as a student of nature), he, however, was a diligent and acute observer of natural phenomena, as we shall show. Simple as these observations were, and crude as their deductions were, with no apparatus or instruments in the aid of the study of these various phenomena of nature, they were precisely the sort of thing and methods that the naturalists were noting and publishing at that time in England, as well as on the continent, and fortunately most of them were really worth noting. The education of the student at the young college in Cambridge did not, in Mather's period, include the first principle as to how to observe nature. Natural philosophy consisted of a little of astronomy, physics and geography and some lessons in geometry. There were no observatories or laboratories, and the student learned directly of nature through books. Botany, zoology, geology and chemistry were hardly even known by their terms as designated. Little need we wonder that science made slow progress, and yet, considering the period historically, the intellectual interest in natural phenomena was manifestly acute. Mather was not a tutor at Harvard, and was not quite at agreement with the form of instructions then given there, for as he said, avoid philosophical romances and get as thorough an insight as you can into the principle of our perpetual dictator, Sir Isaac Newton.

In November of 1712, Cotton Mather prepared a series of thirteen letters of natural and geological history from New England, and addressed these to the secretaries of the Royal Society, namely, John Woodward, an eminent paleontologist, and Richard Waller. There is recorded in the various manuscript books of the Royal Society the fact that Mather had sent a series of 37 communications to the society, but at present we can not take cognizance of them all. Many of them, however, were published in abstract form in the *Transactions* of the society.[10] Mather collected and sent to the museum in 1714 specimens of bones, presumably of antediluvian creatures, fossil teeth and such other subterraneous curiosities as were possible to discover in the unexplored regions of New England. His correspondence with the distinguished secretary, Dr. Woodward, was most timely, as the learned secretary was extremely anxious to procure all natural phenomena that the new colonies could afford. Again, in September 24, 1716, he sent to James Petiver, F.R.S., a distinguished botanist and entomologist, a few dried colonial plants, with observations upon them. This list and comments were published by Petiver with due credit to Mather in his "Nature Collectanea" in 1717. His diligent interest and communications continued to expand to such a large variety of objects that a detailed account of each is not possible in this paper. Mather was also active in observing fauna of New England. His notes on the moose, rattlesnakes, pigeon, worm and fishes, and other specimens of animal life were in-

[10] *Phil. Trans.*, R. S., 29: 62–71, 1714.

cluded in his realm of observation and also such as monstrous births of human beings as well as the lower animals. Mather is probably one of the earliest practitioners in the medical understanding of the treatment of yellow fever. In public print and by private correspondence he gives an account of the method and success of inoculating for smallpox. One of his latest biographers[11] speaks of him as the pioneer founder of the school of inoculation during the frequent smallpox calamities in New England. For this he was persecuted, as many prophets of past ages have been and still are. Mather had secured his information from the Royal Society *Transactions*,[12] and his early training as a physician gave him confidence in its treatment, but the proposal of the method to prevent smallpox infection was startling to many of the learned of the period. Those to whom he gave the treatment responded, and he very hopefully predicted that the results would be the means of preserving many lives. Again, in the realm of physical science, our scholar has left record in the form of letters and notes upon the action of snow, wind, rain, thunder, lightning and the Aurora Borealis. Also a curious account of the action of the moon upon wood is extant. To understand and appreciate more clearly the method and spirit of this Puritan scholar, it is well to read his letter concerning his observations on the details of a remarkable winter in 1717. It is probably one of our best examples of quaintness and his keenness to record all natural phenomena still extant of the seventeenth century writings.

Cotton Mather died in 1728 and lies with his ancestors in Copp Hill burying grounds, Boston.

Paul Dudley, our next ingenious scholar and fellow of the Royal Society, was born in Roxbury, N. E., in 1675 and graduated from Harvard College in 1690, educated for the law. Dudley came from the distinguished family of early founders and governors of the Massachusetts Bay Colony, and himself later became chief justice of Massachusetts. His innate interest in the laws of nature, however, led to his writing on the natural history of New England, including the weather and earthquakes. The appreciation of Dudley's observations and writings, which in all were about 25 papers, led to his being elected a fellow of the Royal Society in 1721. However, all his communications were not published in the *Transactions*, as some of these were merely notes or records of observations for the immediate use of members of the society, who were at all times intensely interested in whatever new came from the virgin land of natural phenomena in the colonies. Simple as these discoveries were, they were, however, entirely new to the fellows whose imaginations were constantly stirred, and consequently their encouragement gave the colonial scholars the needed impetus. In return the colonists received books, especially the *Transactions* of the society. Dudley's first paper[13] sent to the society was an account of the method of making sugar from the juice of the maple tree. The method of drawing off maple sap at that time does not seem to differ a great deal from that of to-day. An interesting feature of Dudley's paper is his final comment on maple sugar, wherein he pointed out that its medical virtues exceeds that of the West Indies sugar. This fact was highly important for the colonists, as in all their studies there was an economic and medical value to be sought. Winthrop, Jr., and Cotton Mather were constantly seeking to

[11] Barrett Wendall, "Cotton Mather, the Puritan Priest," Harvard Press, 1926.

[12] *Phil. Trans.*, R. S., 29: 72–82, 1714.

[13] *Ibid.*, 31: 27–28, 1720.

adapt the juice, bark and leaves of fruit trees for medical purposes. Dudley's keenness for useful recipes of household importance is manifested by his account of a new sort of molasses made of apples;[14] he details the method of preparing and caring for it. This is also a New England invention. Dudley again revealed himself in the order of being the first horticulturist in America.[15] His next communication to the Royal Society was an account of the fruit trees of the fields and orchards of New England. He describes the trees in their physical nature and their fruits in comparison with those of old England. He informs the members of the society of the amount of cider which may be obtained from a certain number of bushels or barrels of apples, and makes further remarks concerning the qualities of pears, peaches and cherries. Also, he describes various other trees to be found in the forest and the method of transplanting by seed or grass. From his garden the vegetables are detailed in general, such as the onion, pumpkin, Indian corn, beans and hops, showing how to plant and grow these by the various experimentation he carries on. It may seem that he anticipates Luther Burbank in the propagation of better fruits, especially in the culture of corn. Dudley writes an interesting paper upon an ingenious method of locating beehives in the forest.[16] This method consists of setting two or more bees free from two different points, after they have acquired some sugar or wax set down for them. The hunter for wild honey then observes the direction of the bees' flight with the aid of a compass, rule and paper. He moves on about a hundred rods distant from the first point and releases the second bee, and again with the compass notices the direction of its flight. The intersection of these two directions or lines will locate exactly the tree in which these bees have their hives. The mathematical certainty of this method, Dudley says, is one used continually by hunters. The bees were originally brought over by the early colonists and were not known by the Indians, at least, there is no Indian name for them, except "the Englishmen's fly."

His next contribution[17] was a paper describing a poisonous wood-tree called "swamp sumach." Dudley, not being a trained botanist, merely gives a local description of this tree or shrub. It was through the botanist of the society, to whom he corresponded regarding his specimens, that he received further comments regarding its scientific nomenclature. Mr. Catesby, in the Carolinas, had sent to the society a quantity of this "Water Shrub," together with the seeds. Dudley writes of the poisonous effects on the body as he observed it on his friends, as well as possible cures. However, he did not in this case actually send a specimen due to the apparent danger of the effect of merely touching or smelling of the wood which would cause inconvenience to the members of the society. The botanist of the society speaks of this plant as a species of *Toxicodendron*.

The rattlesnake was apparently numerous in the colonies, according to Dudley.[18] Again we find his description very complete and accurate and full of scientific interest, especially in the manner of describing their habits and dangerous contacts. It seems that much of this information concerning the moose, deer and snakes as well as plants was obtained through friendly Indians, but in the main through personal investigations which he was quite capable of making, less scientific probably, due to

[14] *Ibid.*, 32: 231–232, 1722.
[15] *Ibid.*, 33: 194–200, 1724.
[16] *Ibid.*, 31: 148–150, 1721.
[17] *Ibid.*, 31: 145–146, 1721.
[18] *Ibid.*, 32: 292–295, 1723.

many cases in which he does not give a physiological description. Methods of dissection and taxidermy in order to make a comparative study of genus and species were not attempted; even in Europe this was not then the mode of scientific work.

The account of the fauna of the new country has been described by other observers, but Dudley seems to have taken very careful notes of the general appearance of the various species, their life and habits, as well as their economic bearing. No anatomical or physiological studies were made, as this did not concern the fellows, with whom at this time zoology as a science was not established; at least, it was not in the colonies. Dudley's knowledge of the moose deer[19] was derived from an all-year study, in which he made observations and comparisons and corrected erroneous information sent by Josselyn.[20]

Dudley's last two communications to the Royal Society were essays of a highly scientific character. He had applied himself with increasing diligence to the study of natural history, which fact is borne out by the high character of his later papers. The first of these two papers is entitled "An Essay upon the Natural History of Whales, with a particular Account of the Ambergris found in the Sperma Ceti Whale."[21] In this paper he describes in detail the physical characteristics, the mode of living and the manner of killing of the several species of whales found along the coast of New England, namely, the whalebone whale, scrag whale, finback whale, bunch or humpback whale, and the sperma ceti whale. He lays more stress on the economic importance of the whales than on their scientific aspect. He enumerates with great care the amount of oil each species produces at various ages and also the amount extracted from the various parts of the bodies. He does, however, mention the medical value of certain parts of the whale, for he states in regard to the sperma ceti whale that

> One of our Country Doctors tells me, that the Tooth of this Fish, shaved or powdered, and so infused in Liquor, equals the Hartshorn, and has been used in the Small Pox, and given to Lying-in-Women, in Case of Sickness, with Success.[22]

The last paper was a letter addressed to the secretary of the society, dated November 13, 1727,[23] which is "An Account of the several Earthquakes which have happen'd in New-England, since the first Settlement of the English in that Country, especially of the last, which happen'd on Octob. 29, 1727." This paper was prepared apparently in obedience to the wishes of the members of the society, for he takes great pains to prepare a historical account of these earthquakes. Since he does not give a very scientific description of the earthquakes, the dates may be of interest. The first quake recorded in New England history seems to have been on June 2, 1638, and in view of the sparsely settled condition of the colony at this time no other earth movements were recorded until 1658, when another earthquake was noted, but Dudley makes no mention of particulars regarding it. He records that on January 31, 1660, another great earthquake occurred, and two years later on January 26, 1662, about six o'clock at night a severe earthquake took place and was followed by two others in a duration of several hours. In 1665, 1668 and 1669 several slight tremors were recorded, but from the last date until 1727 apparently no earthquakes took place.

According to Dudley's reasonings, these quakes were caused by motion of

[19] *Ibid.*, 31: 165–168, 1721.

[20] J. Josselyn, "New England Rarities Discovered," 1672.

[21] *Phil. Trans.*, R. S., 33: 256–269, 1725.

[22] *Ibid.*, 33: 259, 1725.

[23] *Ibid.*, 39: 63–73, 1735.

the earth's crust, but the causes of these earth movements were not clear to him, for in the study of the last earthquake he proceeds to note the weather of the seasons preceding the earthquake. Having noted the temperature, the direction of the wind, the amount of rain, frost and snow, as well as the thunder and lightning, he proceeds to give us a theory which for its quaintness is quoted verbatim.

> By this short Journal of the Weather the Learned will be able to some measure to say, how far our Earth might be dispos'd to, or prepar'd for the Earthquake that followed; first by a long continued Drought and extreme Heat, whereby the Earth became more porous, and abounded with Exhalations or Vapours inflamed, and which afterwards being shut up by the succeeding great Rains and Frost, and thereby hinder'd from an ordinary and easy Passage through the Pores and Common Vents of the Earth, worked so much more forcibly and terribly upon one another. But Philisophers not being yet agreed on the Nature or certain Causes of Earthquakes, I pass on to the second Thing which I proposed to enquire into, Viz. what Kind or Sort of Earthquake ours was. *Gilbertus Jacchaeus* in his *Institutiones Physicae, cap. Terrae Motus* distinguishes Earthquakes into four Species; wherein he agrees with Aristotle and Pliny, with whom the first Species is a Shake or Trembling, and by them liken'd to the shaking Fit of an Ague. I cannot yet hear of any Breach or Opening of the Earth, through the whole Extent of our Earthquake. It has been said by some that were abroad, that the Earth sensibly rose up, and so sank down again; but I much question the Truth of it; for if there had been any such Succussion to raise the Earth to any considerable Height, the Houses would certainly have tumbled down, or the Exhalation forced its Way by some Breach. Nor was our Motion of the Earth that which Aristotle and Pliny call a Pulse or an intermittent Knocking, but one continued Shake or Trembling; and therefore must be ranked under the first Species, viz. a Tremor or Shake, without altering the Position of the Earth, and left all things in the same Posture in which it found them, except the falling down of the Tops of some Chimnies, Stone Walls, etc. without doors; Dishes and some other Things within doors; which I shall observe when I come to speak of the Degree of the Shake.

Crude as his description and theory concerning earthquakes were, the exact truth concerning the causes of earthquakes was not known until some thirty years later, when John Winthrop IV brought out the first scientific explanation of these phenomena.

With several minor communications to the society, Dudley closes his active scientific career, which began in 1720 and ended in 1735, a period constituting a most worthy chapter of pioneer scientific endeavor in the colonies. Dudley's later years were devoted to the practices of the law, and for sixteen years he maintained the tradition of the family in this respect. He died in 1751 and lies buried with his ancestors in the old Eustis Street burying ground in Boston.

In contrast to the placid lives of the preceding scholars, where Calvinism seemed not to have been disturbed by the men collecting specimens and recording observations of natural phenomena, we shall now treat of one who was far above the highest trained minds and theological dogmas of the colony, and who became a storm center, epoch-making in medical history.

Zabdiel Boylston, a self-educated physician, possessed a scientific spirit rare for the age of intolerance to deal with. He apparently did not come under the spell of Puritanism and therefore seemed almost modern in his will to do as his conscience dictated, and this in spite of his close relation to the high priest of Puritanic Calvinism—Cotton Mather. Scientific logic apparently met its antithesis in full force, and to the incredulous it seemed that the doctrine of Calvinism was rudely torn asunder. Boylston was born in Boston in 1679 and received much of his education from Dr. John Cutter, an eminent practitioner of Boston. Young Boylston was not sent to England for his medical training; in fact, the second

generation of physicians were trained by the school of hard experience and self-effort. This system prevailed for over a century in New England before the first medical school was established in 1765.

Boylston will be long remembered for being the first to introduce in the colony a system of inoculation against smallpox, at the great risk of his life and reputation. Boston had during the seventeenth and eighteenth centuries six serious epidemics until the general use of inoculation by transplantation was fully accepted. The original method of inoculation was first published[24] as a contribution by the Royal Society in 1714. This was first noticed by Cotton Mather (then recently elected fellow) during one of the epidemics. Mather, out of despair for his own family, urged the doctors to undertake the general use of the method described. However, so radical were such conditions of treatment that the credulous Puritans hesitated strongly to allow its adoption. The alertness and independence of mind of a man like Boylston did not allow the opportunity to pass in order to find some means to check this dreaded disease. In this new innovation, he was fully supported by Mather and some of the leading scholars. After many secret inoculations as well as open treatment, and regardless of the edict against this method, the dreaded disease was finally checked and the colony experienced its first rational understanding of scientific medicine. The history of the opposition to this practice is an interesting chapter in medical progress in the United States, but only a brief summary of it may be given.

This method was used previous to 1713 by the Turks, Circassians and Georgians, especially so in Constantinople, where the knowledge of its practice was transmitted to England by means of a letter from Emanuel Timonius, M.D. Oxon and Patav, to John Woodward, and presented to the Royal Society by him in 1714. The procedure used in those days may be summarized in a few basic steps:

(1) The vaccine was procured from a young healthy individual who had the smallpox for at least 15 days from the first sickness.

(2) Pus was forced from one of the tubercles into a glass receptor, or vessel.

(3) Pus was then kept at body or near body temperature, until ready for use, which was in one or two hours.

(4) The patient to be vaccinated was placed in a warm room, and several scratches sufficiently deep to draw blood were made on the forearm.

(5) The smallpox pus was rubbed over the scratched area of the skin, taking care to force as much of the pus as possible into the scratches.

(6) The area was covered with some protection, such as a half walnut shell, and the patient was restricted to a diet which excluded meat and broth for at least 20 to 30 days.

(7) Best results were obtained when the vaccination was performed in early winter or spring.

While this method was rudimentary and lacked the important aseptic conditions for safe administration, it was quite successful, and few cases failed to recover from the vaccination.

The method used to-day varies from this, not in principle, but in the application of steps more essential for the safeguarding of the patient. The most important of these is the use of asepsis throughout, including the use of a vaccine which is as sterile as is possible to secure, and absolutely containing no pathogenic organisms. Second is the use of a vaccine which has been attenuated by producing cow-pox in a young calf by inoculation of the smallpox virus, and later collection of the pus

[24] *Ibid.*, 29: 72–82, 1714.

from the tubercles of the cow-pox and using this as the vaccine, instead of the more potent virus from the smallpox tubercle of the human.

After his great success in the treatment or prevention of one of the worst plagues known to man, Boylston visited England, presumably at the invitation of Sir Hans Sloane, then the leading physician of England, and president of the Royal Society. Boylston's reputation was generally acclaimed as the largest and most successful inoculator, but during his stay in England he gave no treatments, fearing he would be misunderstood, but no doubt gave demonstrations before the Royal College of Physicians, of which he was made a member in July, 1726. Boylston published very little in the *Philosophical Transactions,* but at the request of the learned physicians of London he prepared while there an historical account of his work. He did, however, publish only one contribution in the *Transactions* of the Royal Society[25] entitled "Ambergris found in Whales," but it was primarily the pioneer work and experimentation of inoculation for which he was honored as fellow of the Royal Society in 1726. Boylston was not only distinguished as a medical man, but had acquired no mean reputation as zoologist and botanist, and was universally respected and loved because of his moral character and benevolent disposition.

Little remains to be recorded of Dr. Boylston's career after he returned from London in October, 1726. He resumed his practice, which must have been greatly enlarged after the reception accorded him in London, and lived long enough to see inoculation well established and successful, and to know that he was recognized as one of the world's greatest benefactors. He died at the age of 87 years, March 1, 1766, and lies buried in the old cemetery of Brookline, not far from his boyhood home.

A contemporary and associate of Cotton Mather was John Winthrop, a grandson of John Winthrop, Jr. Winthrop was born in Boston in 1681, and graduated from Harvard College in 1700. Nothing seems to be known concerning his early life as a student which would give promise as a scholar, which he later became. That he was interested in natural philosophy was no doubt inspired by the work of his grandfather, who was the observer of the supposed fifth satellite of Jupiter.

Winthrop became a fellow of the Royal Society in 1734, in recognition of his service as collector and student of minerals, and other specimens of geological remains, such as fossils, shells and stones with interesting conglomerations. These contributions which he presented to the society's museum were of inestimable value to the paleontologists and geologists as such in those days. The colony of Massachusetts Bay was then the greatest research field which always caused wonder in the scholars at home as to the natural phenomena they found, not alone in the field, forests and streams, but in the heavens. It is no great wonder that the Royal Society was always ready to acknowledge the real service to science thus rendered by honoring those who supplied material from the unexplored regions. Winthrop was a diligent collaborator with Cotton Mather in collecting specimens, but he himself presented over 600 specimens. He showed scholarship in the method of describing, classifying and cataloguing these specimens in their very general relation to surface configuration. There seems to be no record of any chemical analysis, close study of characterization, classification with respect to their occurrence in nature and reference to their mode of

[25] *Ibid.*, 33: 193, 1724.

formation in rock masses, or alterations which they may have undergone. His observations and remarks, however, upon the medical properties and use of certain minerals, roots and shells were frequently sagacious and just, and therefore great credit should be accorded our first systematic collector of mineral specimens. Imperfect as the science was, Winthrop greatly aided in making progress towards establishing mineralogy as a science. However, the fellows of the Royal Society took occasion to make analysis of the various specimens of minerals and there is recorded that a discovery of certain well-known acids was made. The original manuscript of the catalogue which he prepared with great care is now preserved in the archives of the Royal Society. Selections of this ancient catalogue were printed in the *American Journal of Science.*[26]

The last part of Winthrop's life was spent in England, and there he became a prominent member of the society. He died in London, 1747. A most unusual honor was accorded Winthrop by the secretary of the society, Dr. Cromwell Mortimer, also fellow of the Royal College of Physicians, by dedicating the 40th volume of the *Transactions* to him. In part, Mortimer states:

> Sir,
>
> Personal Friendships and Favours are become the trite Topics of Dedications and public Addresses, as if it concerned the Public to have upon Record the mutual Regard, private Persons may have to each other: Therefore without expatiating here, so far as Gratitude might lead me, on the many Favours you have honour'd me with, I shall confine myself to the Relation Your Illustrious Grandfather had, and Yourself have, to the Royal Society. . . . The extraordinary Knowledge, you have in the deep Mysteries of the most secret Hermetic Science, will always make you esteemed and courted by learned and good Men; but I forbear to say any more, lest the Trouble I have given you by this long Address should be a Trespass upon your Patience; in which Case I know your Goodness will forgive me; and I hope you will be persuaded, that I am upon all Occasions, with the greatest Sincerity,
>
> Sir,
>
> Your most affectionate Friend, and obliged humble Servant.

(To be concluded)

[26] *Am. Jour. Science*, 47: 282–290, 1844.

SCIENCE SERVICE RADIO TALKS

PRESENTED OVER THE COLUMBIA BROADCASTING SYSTEM

THE ROMANCE OF MEASUREMENT

By HENRY D. HUBBARD

ASSISTANT TO THE DIRECTOR, NATIONAL BUREAU OF STANDARDS

WHAT scope there is in measurement, from stars to atoms, measuring the age of the earth, the rate of cooling of our sun, the temperatures of other planets, timing radio echoes from distances beyond the moon—measuring almost everything.

Down the ages from prehistoric times came the art of measuring by which things are dimensioned for utility, by which time and place are measured for every fact and act of life. The measuring stick is a scepter in the hand of science; a tool of discovery, of record and of use of exact knowledge. The gradual rise of the art of measurement gave no sign that in this century it would reach a commanding place in human affairs.

In days of old a poor man in thoughtful mood asked a wise man, "Why am I poor?" The wise one cut a staff thigh high, cut notches in it a hand width apart, gave it to the poor man and said: "I give you the scepter of success, a measuring stick. Measures rule the world. They come in pairs—the measure of the sandal must match the measure of the foot. So all things are made to measure, always two matched measures. Let this stick measure what you make, measure well for use. Three loops of cord make it a balance to weigh what you buy or sell. Set it upright in the sun and the stick will measure the shadow hours of time—allot them thy tasks. Tune thy life to its circling shadows. When in spring the noon shadows grow long is time to plant. Measure your portion and your neighbors'. Make wisely, measure truly, trade justly, and you will prosper."

Thus spake the wise man of the legend. To-day more than ever measures rule, for commerce is the exchange of measured things. Every transaction has five measures—quantity, quality, value, time and place. All are measured—quantity by a number and a unit; quality by measures of its properties; value in terms of weight of gold; place east or west of Greenwich, north or south of the equator, up or down from sea level; and time, in terms of the turning earth, the clock, and of its trip around the sun, the calendar.

Measures are miracle workers, when by matching the measured curvature of glass to the measured defect of the eye we restore sight to the aged and perfect the vision of youth. Success in all things is the matching of a measured means to a measured need, shoe to the foot, glove to the hand, key to the lock. We may measure key and lock to a thousandth of an inch, but some measures need no unit. Without a unit a singer matches by ear the pitch of her voice with that of the piano. Without a unit a violinist varies the length of his strings to play true pitch melodies.

A shoemaker of Old Pekin makes shoes with no unit of measure and no measuring scale. A strip of blank paper and his thumb nail are his measuring tools. He transfers the foot measures to

his paper slip, using his thumb nail as a marker. Skilfully he transmutes these measures into perfectly fitting shoes, without a unit of length.

The Chinese have units of measure, but they differ for each trade and each place. A cloth merchant may buy and sell at the same price. He buys by a long measure, sells by a short measure, and thus makes a profit. The Chinese travel unit, the "li," is longer on easy roads, so that a downhill trip to town may measure fewer "li" than the uphill trip home. The Chinese unit of weight for rice is the "catty," but the unit grows smaller from rice field to tide-water as the coolies carry the rice bags to market. The reason is simple; each coolie takes out his pay in rice. The rice bags reach seaboard lighter for the tax, but weighing the same number of "catty" as when they started.

Crude measures pass, and by modern methods scientists measure accurately how things happen in nature and in experiment—at what heat and pressure a crude oil cracks into gasoline, or carbon dioxide becomes "dry ice," or air becomes a liquid flowing like water, and countless other phenomena occur.

Science makes vast numbers of such natural measurements—melting points of solids, weights of atoms, lengths of light waves, properties of materials. In such measures lie latent the means to alter nature almost at will and make it serve our purpose with almost magical power. Such measures build civilization. They are the numbers which rule the world of enterprise, the unseen frame of all achievement.

Measuring tools evolve from simple origins—a stick, a shadow, a gourd, a stone—to-day they number thousands. They give us new senses, enable us to detect invisible light, to feel magnetic forces, to sense a thousand things otherwise imperceptible. With the cresco-graph one can see the movements of growing plants. A lens-and-mirror device measures the diameter of stars, a feat comparable with measuring a coin fifty miles away.

The radioactivity of radium is measured by the motion of an electrified strip of gold foil, while electrified quartz threads are sent up ten miles to measure cosmic rays. A six-ounce device in a balloon rises sixteen miles to bring back automatic weather records of temperature, pressure, and humidity. We measure air moisture by the stretch of a hair. In the fog-signalling device at the Antioch Light one hundred human hairs are so set that in fog dampness they stretch and thus turn on the signal.

Ingenuity in measuring rarely excels the bit of genius by which we literally hitch our wagon to a star. An automatic device in Paris catches a star's image at meridian, turns its light into an electric pulse, amplified and broadcast as a radio time signal. Time and tide wait for no man. But a marvel among measuring devices takes thirty-seven measured facts set into its mechanism to predict years ahead the height and time of day of all tides for every port of the world. Mathematically minded, this device turns the measures of yesterday into prophecy for to-morrow to guide ships unbuilt on voyages yet undreamed of.

Sound and radio waves are used to measure ocean depths, the thickness of glaciers or the height of the radio ceiling of our air. Radio waves go up with the speed of light and echo back from the magnetic layer of our atmosphere over a hundred miles up. By timing the echo we measure the tides in this magnetic ceiling which may rise fifty miles in a magnetic storm. Echo times indicate that some radio echoes come from distances farther than the moon. Then, too, sound waves are directed to sea bottoms and their timed echoes measure

ocean depths to aid navigation. By similar means the thickness of glaciers is measured by timed echoes of sound sent through the glacier to echo from the rock beyond.

Measures are tools of discovery. One interesting story tells how measures solved the mystery of the breeding place of the Atlantic eel. Out from the rivers swarm the eels each autumn, soon lost to sight at sea. Where they bred, no one knew. Catches of eels were measured from millions of square miles. Measuring their way from all directions men followed the lines of shortening eel lengths to the size of the baby eels—all trails leading to the Sargasso Sea, which proved to be the cradle waters of the eels, a mystery solved by measuring lengths.

Nature does not efface her past. She leaves a record, a history writ in measures. Tree rings thousands of years old reveal the growing weather year by year, climatic history of ancient times. How the rise and fall of tree growth varying in eleven-year rhythms were matched by a similar rise and fall of growth in the number of sunspots also in eleven-year rhythms is an interesting story, for phenomena which vary alike reveal cause and effect relations of profound importance to man.

Measures are great teachers, reducing error, diffusing truth. They dispel error by teaching that a pint's not a pound the world around and never was, anywhere in America; that the needle is not true to the pole; that the so-called "solar constant" is far from constant; and that there are no fixed stars. Measures tell truly how much a pint of liquid weighs, how far the needle wanders from true north, how the solar constant or sun's heat and light vary from day to day; and how many miles a second the so-called "fixed stars" are moving.

Measures teach truth vividly, with almost dramatic effect. We all conceive the atoms as being very small, but we learn how small an atom is when measures tell us, by thirty methods, that a billion atoms side by side measure one inch, or, more startlingly, that if all the atoms in a thimbleful became tennis balls the balls would cover the United States hundreds of feet deep.

Again we all have some idea of the Gulf Stream, but how vastly more vivid it becomes when measures tell us that the volume of flow of the Gulf Stream off Miami is fourteen cubic miles an hour, or equal to one thousand Mississippi rivers in one.

Men who measure do not lack devotion. Countless explorers of nature in the laboratory, the observatory, or at the ends of the earth, in the craters of volcanoes, or in the high air or deep sea sacrifice to gather measures of nature and her phenomena. Galileo "the father of laboratory science" was its first victim. In the great Tokyo earthquake of 1923 the Japanese experts stuck to their work of measuring the earth movements while they could see their own homes going down in ruins and up in flames—a devotion which gave the world its most accurate scientific narrative in earthquake annals.

The engineer puts measures to work in skyscraper, bridge, and other structures. Measures flow through his pencil to scale drawings, each point a location, each line a length to be translated into steel or stone. He matches measured strength against measured stress. Thus by means of measures of strength and dimension the engineer builds his dream of stability into the structure and the architect actualizes his dream of beauty. When the cathedral stands finished, strong and beautiful, we forget the measures, but they remain forever the strength and beauty of the cathedral.

POISON IVY AND WHAT TO DO ABOUT IT

By Dr. JAMES FITTON COUCH

WASHINGTON, D. C.

THIS is the season of the year when mankind becomes acutely conscious of the poison ivy plant. With the coming of spring the nature lover begins his excursions into the countryside, rambling over fields and through woods, and there is an immediate increase in the number of victims of this irritant pest. Some will escape with a few blisters or an itching rash; others will suffer a general reaction accompanied by swelling, chiefly of the face and hands, and may become so seriously sick as to be confined to bed for several days. Ivy poisoning usually is not a serious matter and frequently is a subject for jocularity, the sufferer receiving little sympathy from those unaffected. In a small proportion of cases, however, ivy poisoning may be very serious and may even terminate fatally. Four cases of death from this cause have been reported, so ivy poisoning is not a matter to be taken lightly.

The first thing to do about poison ivy is to learn how to recognize the plant. Many persons, some of them susceptible to the poison, do not identify the plant when they see it. There are a lot of contradictory stories about the appearance of the plant and a variety of common names applied to it, all of which tends to confuse the average individual's ideas on the subject. The plant is called poison ivy, poison oak, poison sumac, poison creeper, markweed, mercury, piery and three-leaved ivy. Sometimes the confusion is increased by applying the name, poison ivy, to plants that do not cause a dermatitis or inflammation of the skin, such as the mountain laurel, which is called poison ivy in some sections of the South.

To begin with, poison ivy is not an ivy at all. This name was applied to it by Captain John Smith, who was blistered by it and who fancied that it resembled English ivy. Poison ivy belongs to a genus of plants that the botanists have named *Rhus*. This genus also includes the common harmless sumacs. About twenty species of the genus are known to produce dermatitis, but only three of them are widespread enough to be of importance in this connection. Two of these are sometimes of shrubby growth and sometimes are found climbing, ivylike, upon walls and trees. In the East the species is known as *Rhus radicans* L. and is popularly called poison ivy. In the mountain states there grows the *Rhus diversiloba* Torr. and Gray, which goes by the name of poison oak. A third poisonous species is poison sumac, *Rhus vernix* L. also called swamp sumac, poison ash, poison elder, poison dogwood and thunderwood. This species grows only in bogs and is therefore less accessible than the other two. It forms a tall shrub or even grows into a tree twenty to thirty feet high.

The first two species that we have spoken of, namely poison ivy and poison oak, may be recognized by the characteristic division of the leaf into three leaflets and by the white berries which may remain on the plants well into the winter months and so serve to distinguish them after the leaves have fallen. "Leaflets three, let it be," is a wholesome maxim for those who roam the fields and forests. The plant known as Virginia creeper is often mistaken for poison ivy but may easily be distinguished by the fact that its leaf is divided into five leaflets. Virginia creeper does not cause dermatitis.

Swamp sumac resembles other sumacs in general and has a more complex leaf than the species just described. Its leaf is divided into seven to thirteen leaflets which are three to four inches long and

decorated with a large midvein of scarlet color. The berries are white like those of poison ivy.

All three of these species contain a milky juice that is capable of raising blisters on the skin. Some people are more susceptible than others and with them the slightest contact serves to provoke a severe reaction. I do not think that any one is immune. My observation has been that those who are so little susceptible that they may handle the plant with apparent impunity will nevertheless be blistered if the juice of the plant comes in contact with tender skin such as that on the back of the hand or on the forearm. Statements are sometimes made that certain races, like the Indians, are immune to poison ivy. There is no real foundation for these stories. People who are not very susceptible to poison ivy should avoid unnecessary contact with the plant because it is known that susceptibility may be developed by repeated contacts and a previously non-sensitive person may become highly susceptible to the poison and may suffer much discomfort as a result.

Animals do not appear to be poisoned. Whether this fact is due to their protecting fur or to some difference in the structure of the skin is unknown, but they may and do roam through thick patches of the plant without painful consequences. Cattle and sheep eat poison ivy, apparently with impunity, and it may be true that the poison is not irritating to the membranes of the mouth and gastro-intestinal tract. Persons may contract ivy poisoning by handling animals that have gone through clumps of the plant. If you are very sensitive to the poison do not pet a strange dog or cat during your rambles in the country. You may brush ivy poison off the fur onto your hands and transport it to other portions of the body.

Sensitive persons may also be poisoned by handling articles decorated with Japanese lacquer which is made from the juice of a species of *Rhus* that grows in China and Japan. A number of cases of this sort has been reported. However, these articles are safe for any one but the most sensitive to handle. There is a wide-spread belief that a sensitive person may render himself immune at least for the season by eating two or three leaves of poison ivy in the spring. This idea comes from the most diverse sources and apparently has some foundation. It is said that the Indians in the Pacific Coast States were accustomed to resort to this precaution every spring and that they never suffered from the plant. Using this idea a method for immunizing people has been developed by a member of the medical profession and good results are claimed for it.

Of course you are thinking, "Why doesn't some one analyze poison ivy, find out what the poison is and then prepare some antidote for it?" Well, the matter is not so simple as it might seem. Many chemists have made careful studies of these plants and have given us much information concerning them. For poison ivy we have the reports of Pfaff[1] and of Acre and Syme[2]; for poison oak, the report of McNair[3]; and for poison sumac the report of Stevens and Warren[4] and the further report of Warren[5]. Beside these reports there is a large number of others that contribute to our knowledge of the subject.

In spite of the immense amount of chemical investigation performed on these plants the poisonous substance has not yet been isolated with certainty in a pure condition. All these investigators obtained oily substances that were very toxic and that would produce blistering in incredibly small amounts. Pfaff

[1] *J. Exp. Med.*, 2, 184, 1897.
[2] *Am. Chem. J.*, 36, 301, 1906.
[3] *J. Am. Chem. Soc.*, 43, 159–64, 1921.
[4] *Am. J. Pharm.*, 79, 499–522, 1907.
[5] *Pharm. J.*, 83, 562–4, 531–2, 1909.

named it "toxicodendrol" and it appears to be present in all species of *Rhus* that can cause dermatitis. All parts of the plant contain this substance. The green berries are poisonous, but the ripe ones do not appear to contain enough to cause blistering. Toxicodendrol is a complex substance that belongs to the group of compounds called phenols by the chemist. This group contains other members that are capable of blistering the skin but none that are so active as this from poison ivy. Since toxicodendrol is soluble in fats in readily penetrates to the lower layers of the human skin where it sets up the painful irritation so well known to its victims. In this connection it is of interest that a patent has been granted for a blistering lotion, the active ingredient of which is toxicodendrol (U. S. 1,559,340).

We are in possession of sufficient knowledge about poison ivy to be able to recommend measures by which people may escape its effects. Every one who is likely to come in contact with the plant should learn to recognize it and should avoid it. Excellent pictures of the three common species are available in Farmers' Bulletin 1,166, issued by the U. S. Department of Agriculture, a copy of which may be obtained gratis by writing to the department. Just ask for Farmers' Bulletin 1,166, or for the bulletin on poison ivy. This bulletin contains, beside the pictures mentioned, a great deal of valuable information concerning poison ivy, poison oak and poison sumac and should be read by every one who is sensitive to these plants.

When poison ivy grows in locations where it is difficult to avoid it, such as along paths, by roadsides, in the garden or near the house, the plant should be eradicated. This may best be accomplished by digging it up by the roots, but other methods are possible for those who do not wish to get so close to such a pest. These are fully described in the Farmers' Bulletin referred to above, and any one interested in eradicating poison ivy should consult that publication.

If a person has accidentally come into contact with poison ivy or the other poisonous species he may get rid of the poison by prompt and thorough washing of the exposed parts with hot water and soap. It is advisable that sensitive persons take this precaution after every excursion into the great outdoors, whether actual contact has happened or not. Sensitive persons may be forced for business or scientific reasons to walk through areas where these plants abound, and some measure of protection is desirable in such cases. The following precautions have been recommended: Dr. McNair suggests that the hands and arms be bathed in a solution of chloride of iron, 10 per cent., made up in equal parts of glycerin and water, before the sensitive person ventures into the ivy areas. Another preventive suggested is to bathe the exposed parts of the skin with a 5 per cent. solution of copperas or ferrous sulphate before visiting an infested place. One should always remember that in the majority of cases it is the hands that come in contact with the plant, getting covered with the poison, which is then carried to any other part of the body which the hands may happen to touch. If one suspects that he has touched poison ivy with the hands he should be careful not to spread the poison by rubbing his face or arms or touching any other portion of the body until he has thoroughly washed off the poison.

When one has become poisoned the event makes itself known by the appearance of numbers of small blisters that itch painfully or by reddish blotches and wheals. The irritation tempts one to scratch and this serves to spread the poison and at the same time to break the surface of the skin and to allow the poison ready access to the lower layers. A large number of remedies has been

proposed for this condition. Many of these are successful in particular cases. In my own experience I have found that an oxidizing agent is the most rational and most satisfactory treatment. The poison is very susceptible to oxidation and if brought into contact with some substance that readily evolves oxygen will be converted into an inert resin incapable of causing blistering. One of the cheapest, most common and harmless oxidizing agents is potassium permanganate, which may be obtained at any drug store. In a strength of 5 per cent. in water this substance is quite effective and, since it stops the itching almost instantly, gives quick relief. It may be applied as a wash, using a piece of absorbent cotton and dabbing it on the affected spots until the itching stops. Blisters should be opened with a sterile needle to allow the permanganate to come in contact with whatever poison is contained inside them. Potassium permanganate turns brown as it gives up its oxygen and leaves a brown stain on the skin. This should be washed immediately after each application. The stain may be removed slowly by washing with soap and water or more rapidly by washing with a 1 per cent. solution of oxalic acid or of sodium bisulphite or of the hyposulphite solution used in photography to fix negatives and prints. Generally one thorough application of the permanganate is sufficient, but in some cases a repetition becomes necessary. Potassium permanganate is harmless to the most delicate skin, especially if the skin be thoroughly washed after each application. After the itching has been stopped the affected area should be allowed to heal. A soothing and antiseptic ointment or lotion may be applied to assist nature in repairing the injured tissues. This treatment will remedy ivy poisoning but the best practice is to shun the plant and avoid poisoning.

WHY CERTAIN SCHOOL CHILDREN ARE BACKWARD

By Dr. C. W. STILES

MEDICAL DIRECTOR, U. S. PUBLIC HEALTH SERVICE

THERE are many different causes which account for the backwardness of school children. Some of these are easily remedied, others are corrected with difficulty, still others can not be eliminated; some are due to economic conditions in the home or in the city or county, others are chargeable to a lack of cooperation with the board of health or with the board of education; some are due to the parents, still others to the teachers or to the child or to the child's ancestors. Whatever the cause in any given case or school or district, every case of retardation is an economic loss to the taxpayers, and the person at fault who does not cooperate with the child in trying to discover and to remove the underlying cause is not only doing the child a grave injustice but is not playing fairly the game of citizenship and self-government with the taxpayers.

The object of this radio talk is to invite the attention of parents and teachers to an easily remediable condition still widespread in certain parts of our country, more especially in the piney wooded sand-lands of the South, a condition which is a serious handicap to thousands of school children, a millstone around the necks of many teachers, a drag to many schools, and a wasteful factor in our taxes spent on public education.

I have recently returned from a

5,524 mile automobile trip, during which I visited 98 white schools, came in contact with nearly 19,000 school children, of whom not less than 20 per cent. showed signs of this easily curable, easily preventable disease which is a potent factor in the backwardness of school children; in other words, at least one out of every five school children I recorded was handicapped by a condition which at a trifling expense could be very easily removed if there were complete cooperation between the parents, the school authorities, the family physicians and the boards of health; and such cooperation would raise the school standards and educational results of the schools and would make it possible for public taxes allotted to the schools to accomplish better results.

I can easily imagine that some of my listeners may possibly exclaim: "What on earth is this crank trying to put across? What does he wish to sell?" The reply is that I refer to hookworm disease, and I am giving you an idea which you can easily test out for yourselves; one which need not worry you if this malady does not occur in your locality. I claim that this idea is not only justified from a purely humanitarian point of view, but is a sound business proposition from the standpoint of the pocketbook of the family, of the school and of the taxes. Hear my story and then inquire of your state board of health whether hookworms are known to exist in your county.

The schools I visited represent the grades or classes known as the first to the twelfth. Some of the grades were divided into three sections (A, B and C) according to pupils' mentality, scholarship or progress in studies. Section A contained the most advanced, section C the most backward and section B the intermediate pupils of the grade.

If, now, I can show that section B contained a higher percentage of pupils showing hookworm symptoms than was found in section A, and that section C contained a higher proportion than section B, I think you will admit that the idea I advance is worthy of your consideration. Assuming that you wish to consider it, I submit the following details:

A. 26 per cent. of the children in section A showed clinical signs which we find in this disease. In general these were rather light cases.

B. 40 per cent. of the children in section B showed symptoms in harmony with this infection. In general these were somewhat more pronounced cases than those observed in section A.

C. 55 per cent. or more than one half of the children in section C, the lowest section, containing the most backward children, showed the symptoms. In general these were the most severe cases of hookworm disease in the schools.

Notice that the percentages (26, 40 and 55) increased as the pupils' efficiency decreased (from A to B to C) and recall that hookworm disease makes for inefficiency, physical and mental backwardness. In all fairness to the children and to the taxpayers do you not think my proposition is worthy of attention?

Let us now turn to a new plan I propose to improve this condition. First of all let me say that the diagnosis of this disease is made free of charge by the state boards of health and by many local boards of health in the states in which this disease occurs. Accordingly, I am not proposing an increased expense to the schools or to the families.

The children who most require examination and medical treatment for this disease can easily be classified by the teachers, without the aid of a physician, into four groups. The first three groups will contain most of the cases which have had the disease for over a

year, while the fourth group will contain the cases of recent infection.

I. In the first group should be classified all children who fail in their school examinations or who otherwise show that they are not keeping step with the progress reasonably expected by the teachers.

II. In the second group should be classified all children who in the opinion of the teachers are "puny," undernourished, underfed or underweight.

III. In the third group should be classified all the girls who are maturing irregularly or slowly.

IV. In the fourth group should be classified all children who have had dew itch or ground itch within a year, especially during the summer vacation.

If the school will collect specimens from these children for microscopic examination by the board of health, the laboratory can easily determine in a few minutes whether or not the individual pupils in these four groups have or have not hookworm disease. Write to your health officer for particulars.

When you receive the report from the board of health show it to the child's parents, who should communicate with the family physician in case the examination is positive, and the child should be treated for hookworm disease. If the report shows that hookworms are not present, you should look for some other cause of your child's condition.

In all probability hookworm disease was introduced into this country by the slaves who were brought from Africa, where it is common among the natives and where it is found also in some of the wild animals, such as the chimpanzee.

Hookworm infection spreads in districts where sanitation is primitive, but good sanitation prevents its spread. If a rural town or county has a mixture of good and of poor sanitation the disease is kept alive among the families living under poor sanitary conditions and may spread to the people, especially the children belonging to families whose homes are provided even with the best sanitation. Some country schools and some country churches with poor sanitation form centers of infection for the entire community. I have known cases among the best educated and the most prominent families of infected counties, in the families of school teachers, of physicians, of lawyers, of clergymen, and in other well-to-do families. I know of a former member of the U. S. Supreme Court and of a very prominent United States senator who years ago had the infection.

Through the altruistic generosity of Mr. John D. Rockefeller, the Southern state boards of health have been able to carry on an intensive campaign against this disease. This has resulted in reducing both the number and the intensity of the cases. But the disease still remains an important factor which should not be ignored.

It is not a difficult matter to discover the causes and methods of prevention of many of our diseases, but even when these are known for a given malady it is often very difficult indeed for the health authorities to induce the people to apply even simple measures to prevent the spread of that malady.

For many years I have argued in favor of controlling hookworm disease, basing my argument chiefly on the harm it does to health. Upon returning from my most recent trip, chiefly through the hookworm counties, I decided on a new plan of argument, namely, to emphasize this disease as one of the causes of backwardness in school children and as an unnecessary and preventable drain on the school tax fund. I hope that those of my listeners who are interested in children, in education, in health, and in taxes will think over the idea I have presented to you.

THE SIZE AND SHAPE OF MOLECULES

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Evidence for Existence of Molecules

Chemists and physicists speculated about the existence of particles of matter for a very long time, and used the idea of the atom and the molecule in their thinking and theorizing, even though there was no very definite evidence for the objective existence of such particles. Within the past fifty years, however, a great mass of rather convincing evidence has been accumulating, which leads to the view that atoms and molecules actually do exist.

If one says that "seeing is believing," there is small chance that one will believe in the existence of atoms and molecules, since they are far too small ever to be seen, even in the most powerful microscope. The smallest particle which can be seen through a microscope clearly enough to be identified as to form and size can not be smaller than about one half the shortest light wavelength to which the human eye is sensitive. This fixes the limit of visibility at a particle of size of about 8/1,000,000 of an inch, or at 0.00002 centimeter, 0.0002 millimeter, 0.2 micron, and 2,000 A°. U. (An Angstrom unit is 1/100,000,000 of a centimeter and is a very convenient unit of length for measuring things as small as atoms and molecules). Now the size of the average atom and molecule is several A°. U. or roughly of the order of a thousand times smaller than the smallest particle visible in the strongest microscope. Necessarily, then, any concepts which we entertain concerning the existence of or the size and shape of molecules are not the result of direct observation but are based on inference.

A few of the arguments for believing in the existence of molecules may now be briefly summarized.

(a) *Diffusion.* If a moth-ball, which consists of the chemical substance naphthalene, is placed on a table in a large room of quiescent air, free from convection currents, not much time will elapse until naphthalene can be smelled in every corner of the room. It would be exceedingly difficult, if not impossible, to explain satisfactorily how this diffusion of the volatile substance could occur on any other basis than that it is simply a case of the escape of molecules (that is, tiny particles) of naphthalene, and a spreading of these molecules in all directions through the air. Such an argument of course does not prove the existence of naphthalene molecules, but it goes a long way toward proving it.

(b) *The Radiometer.* Every one who has looked into a jeweler's shop window has seen the little radiometers which spin around in sunlight. The explanation of this effect takes us back to an experiment performed by Benjamin Franklin when he was living in Philadelphia. One morning after a new-fallen snow, when the warm sunlight was beginning to melt the snow, Franklin went into his back yard and spread out two pieces of cloth, one black and the other white. He observed that the snow melted much more rapidly under the black cloth and concluded that a black surface absorbs sunlight more readily than a similar white surface. Exactly the same principle is involved in our choice of white or light-colored clothes for wear in hot summer weather and in the tropics, rather than black or dark clothes. The same principle enters also into our consideration of the radi-

ometer. The radiometer consists of a small spindle which carries 4 vanes, placed 90° apart, and mounted so that the whole will spin (like a top) in a glass bulb from which most of the air has been pumped out. Every vane is polished on one side and blackened with lampblack on the other. When sunlight or any strong light shines on the vanes, the black sides become warmer than the polished sides, and when the air molecules which are moving about quite freely in the partially evacuated glass bulb strike the warmer side of a vane they acquire a greater velocity of motion and jump away more violently than they do from the polished side. because of this temperature difference. The recoil is sufficient to make the spindle turn. Here, also, it would be very difficult to imagine how this spinning of the radiometer vanes could be set up, if we did not have such things as air molecules.

(c) *Law of Multiple Proportions.* There are many known cases in which one element has the power of combining chemically with another element in different proportions. For example, nitrogen reacts with oxygen to form a series of compounds, the composition of which the chemist indicates as : N_2O, N_2O_2,[1] N_2O_3, N_2O_4, N_2O_5; meaning that 2 atoms of nitrogen are combined in the first compound with 1 atom of oxygen, secondly with 2 atoms of oxygen, etc. There is no question about the fact of such combination in different proportions by weight, and it seems extraordinarily difficult, if not quite impossible, to account for this situation, except by assuming that real atoms do exist.

(d) *Spinthariscope.* A spinthariscope is a little instrument consisting of a zinc sulfide screen near which is mounted a bit of radium. If the screen is observed in a dark room it appears to glow, like a radium-treated watch dial. If one looks at the glow through a magnifying lens one sees millions of tiny, but discrete, flashes of light. These are undoubtedly produced by impact on the screen of the alpha-particles during disintegration of the radium. The alpha-particles are positively charged helium atoms. Seeing the separate flashes produced by impact of individual particles is almost as good as seeing the atoms themselves. It is difficult for any one to look into a spinthariscope and not believe in the actual existence of atoms and molecules. Indeed, Rutherford and Boltwood calculated the *number* of helium atoms in a given volume of gas by actually counting the flashes in a modified spinthariscope.

(e) *Brownian Motion.* If we observe, through a microscope, some dust motes or small droplets of tobacco smoke which are floating in quiet air, we notice that they are dancing about, back and forth, up and down, in and out, with a restless, haphazard sort of motion. This motion, named for an English botanist Brown, who discovered it about 100 years ago, can be explained satisfactorily only by assuming that the suspending medium, in which the motes or droplets are floating, is made up of molecules. These molecules are themselves possessed of a chaotic motion by virtue of their temperature energy, and in the course of their ceaseless thermal agitation they continuously bump into the floating dust motes and jostle them about. This observed Brownian motion is very convincing evidence for the existence of molecules.

Finally, by way of concluding the foregoing brief summary of a small part of the evidence in favor of the existence of molecules, we should, perhaps, point out that the weight of no one of the arguments is completely overwhelming. But taken all together, along with the other arguments that can be marshalled. they are sufficient to convince most minds, even sceptical minds, that matter

[1] This is really NO, but for present purposes the formula may be written as given.

has a fine-grained particle structure. At least we can certainly claim that matter behaves most decidedly as though it is in reality made up of atoms and molecules.

Evidence as to the Size and Shape of Molecules

A good many years ago Lord Kelvin gave a rough scale representation of a water molecule, in order to help us visualize its size. He said that if a drop of water were magnified to the size of the earth, every molecule would have a size somewhere between that of a buckshot and a cricket ball. To-day we can define the minimum and maximum limits of size much more narrowly, and in the case of the water molecule and a great many other molecules we know the dimensions of the molecule and the distances between the centers of the atoms in the cluster of atoms which constitutes the molecule, with considerable exactness. In Lord Kelvin's day it was customary to think of a molecule as a sphere—a tiny "billiard ball." At the present time our knowledge of molecules is so much more detailed that we are quite sure that, although the *atoms* generally do show a spherical symmetry to most of our probes and tests, the *molecules,* especially the molecules of organic substances, seldom appear to be spheres. They have characteristic skeletal shapes of their own, and in fact appear to be shaped very much as the structural formulas of the organic chemist would indicate. Such structural formulas have been worked out, of course, by purely chemical means.

Let us now consider what the physical evidence has to say about the dimensions and spatial configurations of these invisible particles of matter. We shall be able to discuss only a few of the methods that have been developed for gathering this evidence. One of the most powerful of these methods is the x-ray analysis.

I. *X-ray Analysis.* If one holds a piece of mica, which has a laminated structure, so that a beam of monochromatic light, say yellow light, is reflected from the flat mica surface into the eye, one can see a set of alternate black and yellow lines on the mica. This is an "interference pattern." The yellow light is partly reflected from the top layer of the mica, but some of it penetrates and is reflected from the next lower layer, etc., deep down into mica. As the reflected rays come up out of the mica on the way to the eye they fall on top of one another, sometimes in phase and sometimes out of step, depending on the angle of reflection. Hence the striped effect is produced on the mica surface.

The spacing of the black and yellow lines depends for one thing on the distance between the mica layers. One can easily see that the spacing changes when the mica layers are pushed closer together by finger pressure. In fact, if the wave-length of the light is known, as well as the diffraction pattern spacing, the actual distance between the layers can be calculated by using a very simple equation.

In the same way, if a beam of x-rays is reflected from the face of a crystal, for example, of copper, an interference pattern is developed. In the case of x-rays, however, the pattern is not visible but can be caught on a photographic plate, substituted for the eye. From the nature of the interference pattern one can calculate, if the x-ray wave-length is known, the distance between layers of atoms in the copper crystal. Then by letting the x-rays impinge on other faces of the crystal, the spacing of a whole set of intersecting planes of atoms can be determined, and hence the positions of the atoms located very exactly. The distance between two neighbor atoms is thus obtainable. It is found that the atoms in a copper crystal are piled together in a space lattice in

the same arrangement used by many grocers in piling up pyramids of oranges in their store windows, an arrangement known to the crystallographer as "face-centered cubic."

The above extremely crude explanation of the x-ray method may serve to give the reader a rough idea of the underlying principle. This method of investigation has been applied to the study of a large number of crystals, and as a result a great deal of progress has been made in the correlation of physical properties such as density, crystalline form, hardness, ductility, etc., with internal structure of the crystal. Liquids and gases are now also being examined by x-rays by a number of investigators, and these studies are especially fruitful in yielding information regarding the distance between atoms within the molecule.

One of the most interesting crystal lattices (which has been worked out by W. H. and W. L. Bragg[2]) is that of the diamond. The model of this lattice is shown in Fig 1. The balls represent carbon atoms. Every ball is surrounded symmetrically in space by 4 other balls, placed at the corners of a regular tetrahedron. This arrangement, repeated over and over again, gives the entire lattice. The angles between the bonds holding the atoms together are tetrahedral angles, namely, about 109.5°.

It will be noted that the horizontal layers of carbon atoms are "puckered" or corrugated. The arrangement in graphite is quite different. There the layers are flat with all the carbon atoms of a layer in one plane. The atoms in these planes are packed more closely together than in diamond, and the layers are also spaced somewhat farther apart. The slippery, greasy property of graphite is due to the ability of these flat layers to glide over one another. In diamond, however, the spacing of the atom planes is the same in all directions, and there is no tendency for the lattice to flow in one direction rather than in another when it is subjected to stress.

This model (Fig. 1) is made to scale, with 1 inch representing 1 A°. U. The distance between centers of adjacent balls is 1.54 inches, corresponding to a distance in the actual lattice of 1.54 A°. U. If the carbon atoms are spheres, they would have an effective diameter of 1.54 A°. U.

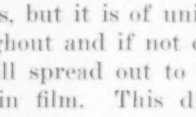
An inspection of the diamond lattice model will show the presence of hexagonal rings, as at ABCDEF. It has been suggested that the benzene ring of the organic chemist has its carbon atoms arranged in the same manner as the diamond ring, which, as can be seen, is a sort of "puckered" ring, with 3 of its atoms in one plane and 3 in another. However, a recent study by Mrs. Lonsdale of the crystal hexamethyl benzene indicates that the benzene ring, in that case, at least, is flat with all 6 carbon atoms in one plane, as in the graphite ring. A model of the hexamethyl benzene molecule is shown in Fig. 2. It seems possible, therefore, that benzene itself may be more properly represented as a flat carbon ring, as in the model of Fig. 3, which also represents 6 hydrogen atoms attached to the graphite ring. This question of the structure of the benzene ring is, however, not yet settled.

Enough has probably now been said to indicate the power of the x-ray method, even in its present state of development, as a tool in our search for evidence regarding the dimensions of and the shapes of molecules.

II. *Oil Films.* Let us now turn to another type of evidence. It is well known that if gasoline or kerosene or paraffin oil, or in general any other mineral oil, is placed on a water surface, it will spread fairly readily to give a pool or lens of oil. If, however, a vegetable or animal oil, such as castor oil, peanut oil, cotton seed oil, sperm oil, or

[2] W. H. and W. L. Bragg, *Proc. Roy. Soc.*, 89A: 277, 1914.

lard oil, etc., is dropped onto a clean surface of water, a film of an entirely different sort is produced. The film is not thick in the middle and tapering out at the edges as in the case of a mineral oil lens, but it is of uniform thickness throughout and if not confined too much it will spread out to give an extremely thin film. This difference in behavior of the two sorts of oil is due to a difference in the nature of their molecules. The molecule of a mineral oil consists of a long chain of carbon atoms with hydrogen atoms attached to every carbon atom in this way,



Gasoline is made up of a mixture of such hydrocarbon molecules averaging about 7 carbon atoms per chain, although high test gasoline contains molecules with only 5 or 6 carbon atoms. The average kerosene molecules are much longer, of about 11 to 17 carbon atoms, vaseline still longer, paraffin even longer.

None of these materials is soluble in water, and so when such an oil is poured on water, we would expect the oil molecules to be piled together in a haphazard way on the surface like so many sticks of wood. But the vegetable and animal oils have molecules which differ, in general, from mineral oil molecules in one important respect. They, too, consist of long carbon chains, but attached to one end of the chain are some oxygen

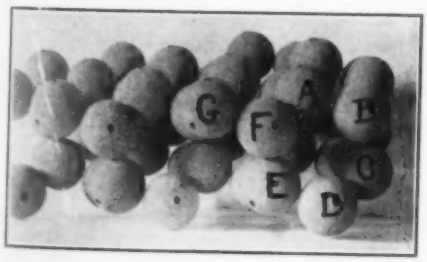


FIG. 1

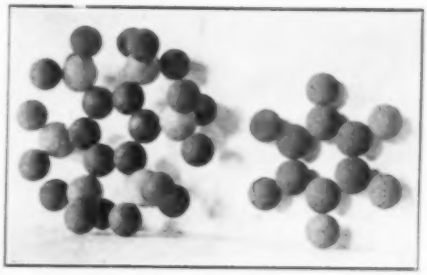
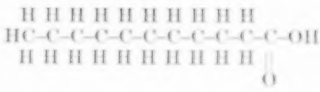


FIG. 2 FIG. 3

atoms as shown in the following formula:



These oxygen atoms are soluble in water, and they confer solubility on one end of the molecule; but the rest of the carbon-chain molecule remains just as insoluble as ever. As a consequence of this, when vast numbers of these molecules are placed on a water surface, the molecules all stick one end into the water and the rest of the molecule into the air so that they are all standing up on end or are orientated, as in Fig. 4.

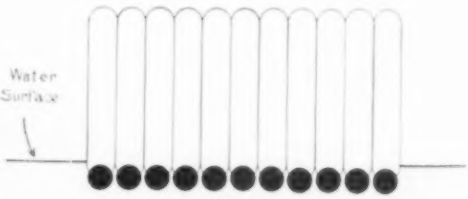


FIG. 4

where we represent the carbon chain by a vertical column and the oxygen bearing group by a black circle. Such a picture of a marshalled array of oil molecules explains why the oil tends to *spread:* every molecule wishes to dip its soluble head under water. Furthermore, for the same reason, the film is one molecule deep; that is, the thickness of the oil film is the length of the carbon chain.

Dr. Langmuir,[3] of the Research Laboratory of the General Electric Company, who was largely responsible for bringing this previously rather vague and hazy picture of oil film structure to a definite, clear-cut focus, has calculated the dimensions of the oil molecules. This may be done very simply. If we divide the area over which the oil spreads (when the film is pressed together tightly by a lateral pressure at the edge of the film) by the number of molecules in the film, we obtain the cross-sectional area of the molecule as we look down on it from above. If the volume of the film, which may be assumed to be the same as that of the oil before it is dropped onto the water surface, is divided by the area of spread, we get the thickness of the film, or the length of the carbon chain. The results for the stearic acid molecule, which has a chain of 18 carbon atoms and 2 oxygen atoms at the end, give a length of 22 A°. U. and a cross-section of about 5 A°. U. × 5 A°. U., indicating clearly a rod-shaped, or long cylindrical, molecule.

Chemical analysis gives the number of carbon atoms in the molecule. Division of the length of the molecule by the number of carbon atoms in the chain would naturally be considered to give the length of each link, or, in other words, the distance between centers of two adjacent carbon atoms. From a considerable number of measurements of molecules of various lengths, Dr. Langmuir obtained the result that this single link length is about 1.2 A°. U. This result was very surprising, since it is much smaller than the distance between centers of adjacent atoms in the diamond lattice. It hardly seems likely that the carbon atoms in soft, buttery materials like these oil films are packed more closely together than in a hard, dense substance like diamond.

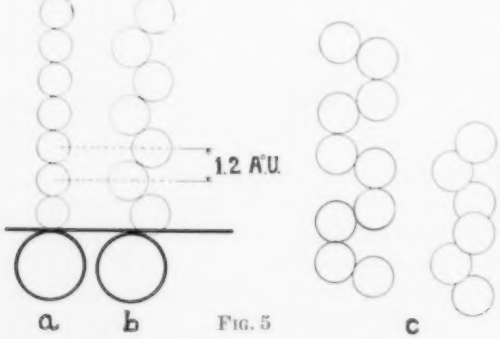


FIG. 5

Dr. Langmuir indicated the way out of the difficulty. What was being measured was not the actual distance between atom centers in the chain molecule, but the *vertical* distance. The molecule chain is not to be represented as at (a) in Fig. 5, but as at (b). The carbon atoms are arranged in a zigzag chain, and if the angles of the zigzag are tetrahedral angles, and the actual distances from center to center 1.54 A°. U., then the vertical distance is about 1.2 A°. U. In the diamond lattice, Fig. 1, one can see a zigzag chain of this sort, namely GFAB.

A few years after Dr. Langmuir's experiments, Müller and Shearer,[4] working in Sir William Bragg's laboratory, showed by x-ray analysis that long hydrocarbon chains could assume various types of zigzag shape, as at (c), Fig. 5, and could even be twisted into a spiral. The angles between the bonds remain tetrahedral throughout, and the variations in shape are produced by mere rotation of the carbon atoms about the bonds, in just exactly the same way that one could stick two oranges, one on one end of a lead pencil, and the other on the other end, and could turn them on the pencil as an axis.

The rubber molecule has been shown to be a long hydrocarbon chain, although somewhat different from those we have just been discussing. Recently

[3] Langmuir, *Jour. Am. Chem. Soc.*, 39: 1848, 1917.

[4] Müller and Shearer, *Jour. Chem. Soc.*, 123: 3156, 1923.

Dr. Hauser[5] interprets the x-ray diffraction patterns obtained when rubber is stretched and unstretched as meaning that the rubber molecule is coiled up in a helix before stretching, and becomes pulled out during the stretching process.

Thus, one can see how the oil film experiments either alone, or in conjunction with x-ray analysis, have led to a very definite picture of a long stick-shaped hydrocarbon chain, with its carbon links staggered in a zigzag, or wound up in a helix. This picture of a molecule is far different, as far as the *physical* evidence is concerned, from that of Lord Kelvin's day. The idea that one part of a molecule may be different from another part of the same molecule, as in the stearic acid molecule, where one end is soluble in water, and the rest is not, is destined also to play a most important rôle in modern theoretical chemistry, and consequently also in modern practical chemistry. As illustration of the power of this idea let us consider two examples.

1. Stabilization of Emulsions: As we already know, kerosene is insoluble in water. If quantities of kerosene and water are shaken up violently together in a bottle there is formed what we call an emulsion of kerosene in water. Such an emulsion, however, is not stable. The droplets of kerosene soon coalesce and separate from the water into a layer. But if a small bit of soap is present in the bottle while the shaking is going on, the emulsion becomes quite permanent. Now this stability which the emulsion acquires with the soap's assistance may be explained quite convincingly in terms of the same sort of orientation of molecules which we have just employed to account for the spreading of animal and vegetable oils. A molecule of soap is exactly like the molecules of Fig. 4, except that the hydrogen atom in the COOH group at the end of the molecule has been replaced by the atom of some metal, for example sodium or potassium. Now, when soap molecules, let us say of sodium, are mixed with the kerosene and water emulsion the carbon chain part of the soap molecules will stick through the surface into the kerosene droplets, since it is quite a general rule that "like dissolves like." But the COONa is soluble in water and is not soluble in kerosene, so that we would

FIG. 6

expect to have the convex surfaces of all the little kerosene droplets coated with molecules of sodium soap very much like pins sticking into a pin cushion, as in Fig. 6. Naturally then, since the whole outer surface of the droplet is plastered over with soluble groups we are not surprised to find that the whole droplet has become soluble in water and will remain suspended indefinitely with much less tendency to coalesce with other droplets and form a kerosene layer.

It is very interesting to note that the detergent action of soap is probably due to exactly this effect we have just de-

[5] Hauser, *Jour. Ind. and Eng. Chem.*, 21: 249, 1929.

scribed. When we attempt to cleanse our skin, for example, by washing with water alone, the difficulty lies not in washing off "the dirt," but in removing the oil and grease exuded through the pores of the skin or collected on the skin by outside contamination. These oils and greases do not dissolve in water, even in hot water, and it is the function of the soap to emulsify these substances and render them soluble in just exactly the same way as in the case of kerosene.

2. Lubrication: When a clean metal shaft turns in a clean metal bearing, there is a good deal of friction, and if the two rubbing surfaces are made of the same kind of metal, and especially if the load is a heavy one, a great deal of "seizing" and actual biting of one surface into the other is likely to occur. But if some oil is introduced between the shaft and bearing, the surfaces no longer contact. They turn on the film of oil. The flow has ceased to be "plastic" and has become "viscous." The friction is enormously reduced.

Such an oil film, if it consists of kerosene or vaseline or paraffin, or in general of merely a hydrocarbon, will not serve as a satisfactory lubricant in machines where the frictional load is very heavy. The great pressure will rapidly squeeze the oil out of the bearing. Under these conditions it has been found that vegetable oils such as sperm oil, lard oil, castor oil, etc., are much more efficient. The oxygen bearing groups at the ends of these molecules, the same groups that are soluble in water, groups which have a strong field of force, attach themselves firmly to the metal surfaces, and anchor the oil molecules. To such an extent is castor oil used as a lubricant for the automobiles in the great races at Indianapolis that these races have come to be known as the "castor oil derby."

III. *Collision Areas.* Another promising method of arriving at conclusions regarding the sizes and shapes of molecules involves a determination of their collision areas.

Suppose we have a long capillary glass tube of very small bore, and we let a gas or vapor at a certain observed pressure p_1 flow through the capillary at constant temperature to a region of lower pressure p_2. If, in addition, we know the dimensions of the capillary and the time required for a measured quantity of the gas to flow through, we can obtain the "viscosity" of the gas at the particular temperature. Now, the viscosity of a gas increases with rising temperature, and if we can get the viscosities over a considerable temperature range, we can calculate the collision area of an individual molecule, that is, the target area which it presents to bombardment by its neighbor molecules, as it tumbles through the capillary tube. The application of this method to the experiment determination of collision areas of molecules has been largely developed by the English physicist Rankine.[6]

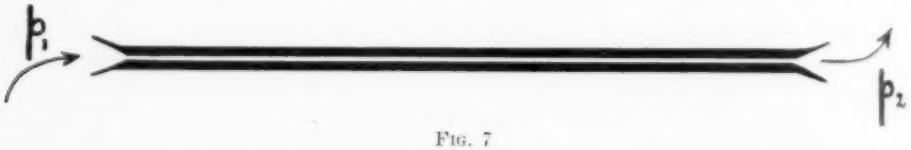


FIG. 7

If we add saw-dust to a small stream of water, no appreciable slowing up of the flow occurs, but if we add leaves, or twigs, or large pieces of wood, we may set up considerable obstruction to the flow, and in fact even dam up the stream entirely. So also in the capil-

[6] Rankine, *Proc. Phys. Soc.*, 33: 362, 1921; *Proc. Roy. Soc.*, 98A: 360, 1921, and many other papers.

lary tube. The larger the gas molecules, the greater will be the entanglement and rubbing of molecule with molecule, and the greater will be the viscosity, or resistance to flow. This picture may be considered to give, in a crude way, the physical basis of the calculation of the molecule collision area.

In Table I are listed the collision areas of a number of molecules, determined by several investigators. The areas are expressed in square Angstrom units.

TABLE I

	Collision Areas sq. A°. U.	Shadow Areas sq. inches	
1. Methane, CH_4	7.72	7.6	(Fig. 8)
2. Ethane, C_2H_6	10.6	11.3	
3. Ethylene, C_2H_4	10.3	10.6	
4. Benzene, C_6H_6	19.0	19.2	(Fig. 3)
5. Cyclohexane, C_6H_{12}	21.9	23.2	

The collision area gives a good idea about the size of the molecule, but does not, of course, tell anything about its shape. As far as this experimental result is concerned the molecule could be spherical or stick-shaped or cubical or of any other shape. However, by a special supplementary treatment of the result, it is possible to arrive at interesting and definite conclusions regarding the molecular shape.

Let us make a model, for example, of a methane molecule. We shall make it to scale, one inch for an Angstrom unit. We take a ball out of the diamond model of Fig. 1, and attach to it 4 balls representing hydrogen atoms placed at the 4 corners of a regular tetrahedron. The model is shown in Fig. 8. The effective diameter of the hydrogen atom is taken to be the same as that deduced from x-ray analysis of naphthalene and anthracene, namely about 1.35 A°. U.

FIG. 8

Now the model is mounted in a support, as shown in Fig. 9, in such a way that its shadow can be thrown on a paper screen. The model, by a motion of rotation, and a dipping, is brought into

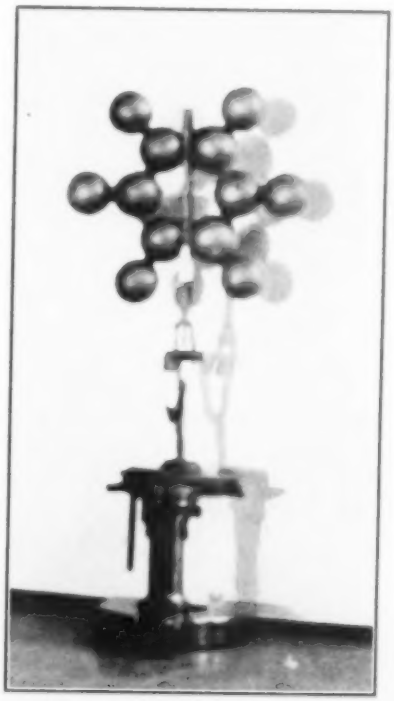


FIG. 9

a large number of different positions so that its average shadow area, or average cross-sectional area can be determined. This is done by drawing the outlines of the separate shadow areas with a pencil, and then measuring their areas with a planimeter, adding up all the areas, and dividing by the number of shadows.

If the model is a good one, that is, if it fairly represents the molecule, there should be a good agreement between the average shadow in square inches and the collision area in square A°. U., as determined by the viscosity method. Table I indicates that this agreement is very good indeed in the case of a number of molecules that have been studied. The reader will readily see how such a combination of the shadow method with the collision area results can be used to test proposed molecular models of various shapes. The method promises to be especially useful in determining the spatial configuration of large skeletal groups in complex organic molecules.

There are many other methods which have been employed to gather evidence regarding molecular size, such as liquid density measurements, and determination of the quantity "b" in van der Waals' equation of state; and also regarding both size and shape, such as dielectric constant and infra-red absorption measurements.

This brief article may serve to convince the reader that we are able to draw certain definite quantitative conclusions, which seem to be consistent and justifiable, about the sizes and shapes of the invisible molecules. These studies are becoming increasingly important. The size and shape of the molecule undoubtedly play an important part in many chemical and physical and vital processes, such as surface tension, viscosity, adsorption, solubility, rate of solution, permeability, diffusion, heat of fusion, heat of vaporization, rate of chemical reaction, catalysis, enzyme activity, colloid particle building and many other related phenomena.

THE PROGRESS OF SCIENCE

THE JUBILEE INTERNATIONAL POLAR YEAR

THE proposed second International or Jubilee Polar Year, 1932–33, is sponsored by the International Meteorological Organization. Following suggestions made in 1875 by Lieutenant Karl Weyprecht, of Austria, this organization also arranged for the first International Polar Year of August, 1882–1883. The immeasurable enhancement in the scientific worth of polar expeditions through pooling of effort in simultaneous physical observations during a full year at many stations in high latitudes over isolated stations occupied even for long periods has been shown by the theoretical and practical applications of some twenty volumes of data obtained during the first International Polar Year. Thus the present magnetic charts of the Arctic are based to a great extent upon this work and the meteorological charts obtained have been the basis of many notable studies in weather-forecasting. The United States took part, together with eleven other countries, in the program of the first Polar Year by establishing two stations (Point Barrow, Alaska, and Fort Conger, Ellesmere Island) in a total of fourteen to twelve in the Arctic and two in the Antarctic.

Founded in 1872, the International Meteorological Organization, consisting of directors of national meteorological and geophysical institutions, has been for sixty years of world service in coordinating national efforts for practical applications of meteorology, in the preparation of improved magnetic charts, and in the development of upper-air observations now becoming so essential to modern meteorology and to air-transportation. At Copenhagen, Denmark, September, 1929, the organization, with official representatives from thirty-four countries present, unanimously adopted a resolution emphasizing the need for a second International Polar Year.

Geophysical sciences have made such rapid progress in the present century and so many new problems demanding solution have arisen that pooling of international resources now must yield much greater scientific and practical profit than realized fifty years ago. Instruments and methods of observing and recording have greatly improved. The practical and economic value of further studies of the magnetic and electric fields of the earth, particularly in its higher atmosphere, which can best be observed under the unique conditions prevailing near the magnetic poles, have been indicated through the definite relations both progressive and irregular changes in these fields have with upper-air conditions and through the correlations of their variations with solar changes affecting both wired and wireless transmission and reception. The interaction of air-masses of different origins and properties and the effect of these interactions on the weather, the circulation of the atmosphere in high and low latitudes, variations in the ozone layer, and many other problems will find increased understanding through simultaneous world-wide endeavor for meteorology, even though the period set is but a year. Such endeavor, perhaps in a lesser degree, must, however, yield useful data in geology and geography through the magnetic and earth-current work at many stations on the structure of the earth's crust and the delineation of new geographical features and perhaps of geo-

MEETING OF POLAR COMMISSION AT LENINGRAD, U. S. S. R., AUGUST, 1930

MAGNETIC SECTION, LEFT TO RIGHT: ROSE, TANAKADATE, OBOLENSKY, SCHOKALSKY, KHUZEOWILL, KERÄNEN, LAURSEN, HARRADON, MAURAIN, FLEMING, LA COUR, WEENBERG.

graphical features as modified in the past fifty years.

The development of the program has been entrusted by the International Meteorological Organization to its International Polar Year Commission for 1932–33. Dr. D. la Cour, director of the Danish Meteorological Institute, is president of this commission, which has two representatives from the United States in a total of thirteen (Captain N. H. Heck, of the United States Coast and Geodetic Survey, and J. A. Fleming, of the Carnegie Institution of Washington). The cost of the preliminary work and publications has been borne by the International Meteorological Organization and by the Danish Government. The first printed report of the commission[1] covers the transactions of its meeting held at Leningrad in August, 1930, and includes a history of the effort and its organization, resolutions adopted for the guidance of the work, and appendices giving in detail reports and recommendations regarding schemes of observation in various fields, equipment and general plans for observatories and quarters. Subsequent circular reports and letters (to be printed in later reports) deal with instructions for each field of observation, development of special photographic equipment, methods and style of publication, etc. The commission's attitude to systematically prepare for the utmost profit in the most economical use of the opportunity and funds is reflected throughout these.

The program proposed recommends establishing forty-three stations in the Arctic region, while in the Antarctic region—so much more difficult of access—it is proposed to establish at least five stations in addition to the permanent one now operated by the Argentine Government in the South Orkneys. Twenty-six nations have thus far indicated that either their governments or their national academies of science may participate by organizing special stations or by intensifying programs of observation at their existing stations. Twenty-one of the Arctic stations and two of the Antarctic stations have been assured already. Additional stations other than those recommended, which may possibly take part in all or part of the program, are on the west coast of Greenland under the direction of Professor Hobbs, of the University of Michigan, near the most northerly part of Greenland by a Danish expedition, and stations on Canary Islands by Spain, on Fernando Poo Island by Spain, and on Easter Island (Pacific Ocean) by Chile. About fifty-five regular magnetic and electric observatories located at various parts of the temperate and torrid zones will participate. Thus the program proposed involves over one hundred widely distributed stations in all parts of the world.

The commission has asked that, if possible, the United States participate by occupying (1) a station in Alaska at or near Fairbanks to take the place of Point Barrow and (2) the station of 1882–83 at Fort Conger in Ellesmere Island. After careful scrutiny and study of the statements submitted in writing in November, 1930, to the United States Department of State by Professor A. E. Kennelly and the writer, the secretary recommended on February 9, 1931, an appropriation of $30,000 for an observatory and necessary instruments and for pay and transportation of personnel to establish the station near Fairbanks. President Hoover favorably endorsed this recommendation in a special message to Congress on February 10, 1931. The

[1] Premier rapport de la Commission Internationale de l'Année Polaire 1932–1933. Leyde, Secrétariat de l'Organisation Météorologique Internationale, No. 6, iv + 152 (1930).

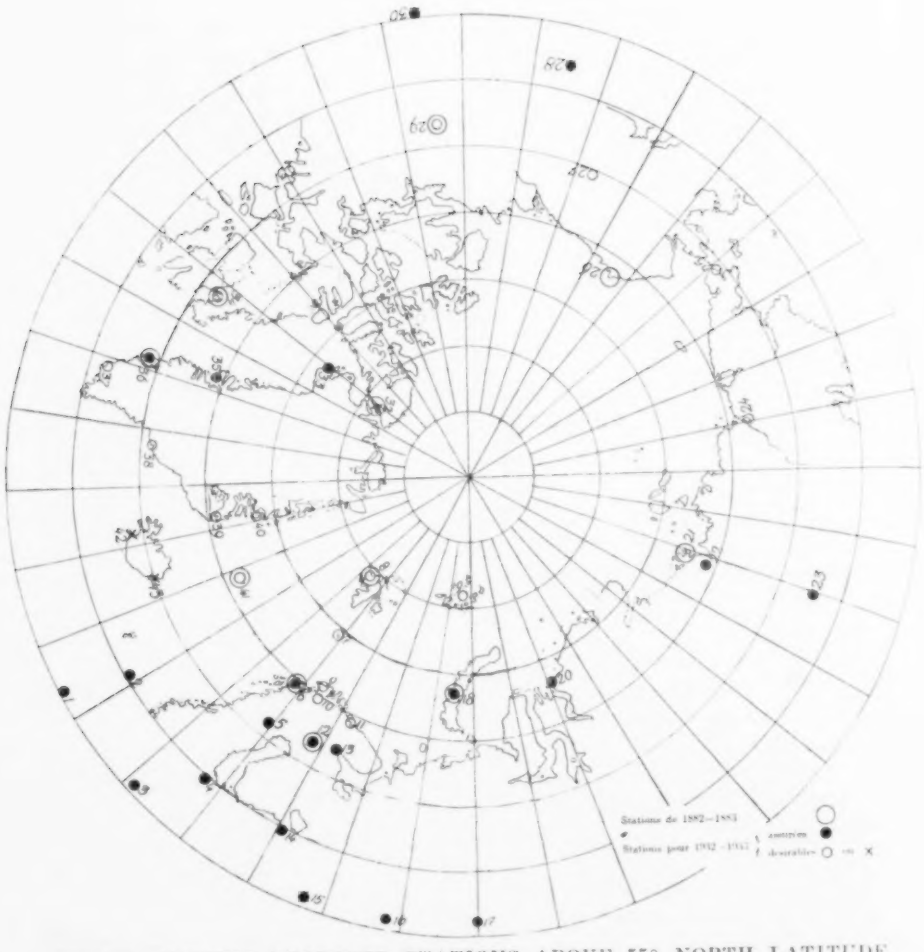


CHART SHOWING PROPOSED STATIONS ABOVE 55° NORTH LATITUDE

1, ESKDALEMUIR; 2, LERWICK; 3, RUDE SKOV; 4, LOVÖ; 5, ABISKO; 6, BOSSEKOP-TROMSÖ; 7, BEAR ISLAND; 8, CAPE THORSDEN; 9, HAMMERFEST; 10, KAUTOKEINO; 11, PETSAMO; 12, SODANKYLÄ; 13, KANDALAKSCHA; 14, SLOUTZK; 15, KOUTCHINO; 16, KAZAN; 17, SVERDLOVSK; 18, MATOTSCHKIN SCHAR; 19, HOOKER ISLAND; 20, DICKSON; 21, MOUTH OF THE LENA RIVER; 22, BOULOUN; 23, YAKUTSK; 24, NIJNI KOLYMSK; 25, YELLEN (EAST CAPE); 26, POINT BARROW; 27, FAIRBANKS; 28, SITKA; 29, FORT RAE; 30, MEANOOK; 31, CHESTERFIELD; 32, FORT CONGER (LADY FRANKLIN BAY); 33, CAPE YORK (THULE); 34, KINGUA FIORD; 35, GODHAVN; 36, GODTHAAB; 37, IVIGTUT; 38, ANGMAGSSALIK; 39, SCORESBY SOUND; 40, MYGGBUKTA; 41, JAN MAYEN ISLAND; 42, REYKJAVIK; 43, SEYDISFIORD. THE ANTARCTIC STATIONS PROPOSED INCLUDE: NEW YEAR'S ISLAND; ORCADAS, SOUTH ORKNEYS; KERGUELEN ISLAND; MACQUARIE ISLAND; CAPE ADARE OR LITTLE AMERICA; TRISTAN DA CUNHA.

appropriation contemplates employment of the personnel some time before the beginning of the Polar Year to insure training and preparation of buildings and equipment as well as after the completion of the field work to compile and publish the results. The Senate passed the proposed bill, but, although the House Committee on Foreign Affairs unanimously reported it favorably, the parliamentary jam at the end of the session prevented its passage by the House. Preparations have been made to have the bill considered as soon as possible in the coming session of Congress. It is hoped that occupation of Fort Conger may be effected through a private American expedition with funds subscribed from various sources.

The proposed program has the unanimous support of the American Geophysical Union and of the International Union of Geodesy and Geophysics, as expressed in resolutions adopted by the former in May, 1930, and by the international body at its Stockholm Assembly in August, 1930, with some 302 delegates representing thirty-six countries in attendance.

That department of our government primarily interested in this work is the Department of Commerce, work of similar kind being done under its auspices by the Coast and Geodetic Survey. Other departments which have a vital interest in the Polar Year program are: The Department of the Navy, through its research laboratory, in the study of magnetic and auroral effects on radio transmission; the War Department, through its signal corps, in the development of radio and meteorological work in Alaska; the Department of the Interior, through its interest in development of resources in the territory of Alaska; the Department of Agriculture, through its weather bureau, in meteorological investigations; the Post Office Department through its air-mail service in the north, and the Department of State in its strengthening of international relations and good-will. There are, besides these governmental departments, many organizations in the

MEETING OF POLAR COMMISSION AT LENINGRAD, U. S. S. R., AUGUST, 1930
METEOROLOGICAL SECTION, LEFT TO RIGHT: KLADO, ARNOLD-ALABJEW, KALITIN, TIMONOFF, SCHOKALSKY, KAMINSKY, HERGESELL, JACKSON, DOMINIK, SIMPSON, SVERDRUP, WANGENHEIM, SCHULEIKIN, MOLTSCHANOW, KARTZEFF, TOLMATCHEW, SOKOLOW.

United States greatly interested, for example, the National Academy of Sciences, the Institute of Radio Engineers, universities interested in geophysics and its applications in geological investigations such as the Massachusetts Institute of Technology, Harvard University, California Institute of Technology, Colorado School of Mines, etc. Commercial organizations interested are represented particularly in the communication field and include, among others, the American Telephone and Telegraph Company, the Western Union and Postal Telegraph companies, and companies engaged in air transportation.

Upon completion of the Polar Year and publication of all the resulting data by individual governments and organizations occupying stations, it is essential that provision be made to coordinate, reduce, compile and tabulate the data under the direction of the International Polar Year Commission. Following publication of results at individual stations, the data should be separated and distributed to internationally known specialists for study and discussion. Reports from these to the commission on discussions and conclusions would permit general coordination of findings giving their true scientific and practical value and insuring their consideration in the broadest aspects. This and the publication and distribution to all governments and organizations taking part will require a considerable fund for computational and clerical assistance to the specialists and adequate publication of results, which will constitute in the largest sense distinctly cooperative and international effort.

J. A. FLEMING

THE NEW RESIDENCE FOR MEDICAL STUDENTS AT COLUMBIA UNIVERSITY

THE latest addition to the imposing group of buildings comprising the Columbia University-Presbyterian Hospital Medical Center in the City of New York bears the following inscription:

This Building is the Gift of
Edward S. Harkness of New York
and Named in Honor of
Samuel Bard
First Professor of Medicine in King's College
1767–1776
Servant of Columbia College for Forty Years
as Professor
As Trustee and as Dean
of the Faculty of Medicine

Bard Hall, the residence for men medical students and officers of the College of Physicians and Surgeons of Columbia University, is situated on Haven Avenue at 169th Street. The exterior of the building is of light-faced brick with limestone trim, and the design has been kept in harmony with the other buildings of the Medical Center group. The building is erected on the side of a steep hill, the summit of which is 161 feet above the river, which allows for three stories below and fourteen stories above the Haven Avenue level, four of which are in the tower surmounting the building. The windows on the north, west and south façade afford a magnificent and unrestricted view of Riverside Park, the Hudson River and the Palisades.

The two lower stories contain the gymnasium, swimming pool, squash courts and locker rooms. The story below the entrance contains the main dining room, three private dining rooms and ample kitchen and serving facilities. The entrance floor accommodates the lobby, offices and coat rooms, the main lounge and the grill room with loggia and terraces overlooking the river. There are about fifteen bedrooms on the first and second stories in the north wing, which also includes a dormi-

BARD HALL.

tory for students who are on emergency duty in the hospitals. The main bedroom floors comprise the third to tenth stories inclusive and are similar in general arrangement, each including twenty-five bedrooms, four studies, one tutor's suite and a social room, together with conveniently grouped toilets and shower baths. The eleventh story comprises six studies, seven bedrooms, with private baths, and the rooms of the P. and S. Club (Student Y. M. C. A.). The twelfth story contains one apartment, and the two upper tower stories accommodate the machinery room, the fan room and the water tank. All floors are served by two electric elevators.

The bedrooms are of good size, contain clothes closet and lavatory, with hot and cold running water, and are completely furnished. A few rooms have private studies with wood-burning fireplaces. The facilities of the hall include large lounging rooms, dining room, cafeteria and grill rooms, gymnasium, squash courts and swimming pool. Special consideration has been given to the selection of the furniture, rugs, draperies and decoration for the public rooms, tutors' suites, with a view towards comfort, simplicity and harmony.

Each of the tutor's suites consists of a bedroom, bathroom and large living room with a wood-burning fireplace and a well-equipped serving pantry directly connected by electric dumbwaiter to the main kitchen, and the living room is of such size that groups of from twelve to twenty students may gather for discussion before the open fire.

Open roof spaces for rest and recreation are provided on the third floor over the lounge and on the tenth floor opening out from the P. and S. Club, and the building is so planned that should there be demand for more accommodation in the future, it will be possible to erect a wing on the south side of the plot which will provide for 150 additional residents.

HENRY LEE NORRIS

THE DINOSAUR SKELETON AT THE PEABODY MUSEUM

THE skeleton of *Brontosaurus excelsus* Marsh, recently mounted in the Peabody Museum of Natural History at Yale University, is a most imposing specimen. The bones of this great four-footed herbivorous dinosaur are original, except for the restoration of minor parts, and the skeleton as a whole comprises the most perfect single specimen of this huge form extant. In addition, it is the largest dinosaur so far mounted in any museum. The animal had a length on the curve of the backbone of not less than seventy feet, a height over the hips of about sixteen feet, and an estimated weight of from thirty-seven to forty tons in life.

Fifty years ago this specimen was found in the rocks at Como Bluff, Wyoming, by William H. Reed, a veteran collector for Professor O. C. Marsh. The first box of these bones arrived at the museum on May 20, 1881. The preparation of the skeleton—freeing it from the matrix, piecing together the innumerable parts into which the bones were broken, restoring some of the missing processes, and so on—has taken several years of the most patient and painstaking labor.

This type of dinosaur is characterized by a long neck and tail, with a comparatively short body borne on four ponderous elephantine limbs. The fossilized bones of the animal weigh approximately six tons. This great load is carried on but two uprights, which are borne on a steel grid that touches the floor at only twelve points. The vertebral column lies on an H-beam, bent to fit the curve, and the beam rests on the two uprights. The entire steel

THE DINOSAUR SKELETON AT THE PEABODY MUSEUM.
PROFESSOR R. S. LULL, DIRECTOR OF THE MUSEUM, IS STANDING AT THE LEFT UNDER THE SKELETON.

framework is riveted together to form a solid unit. This method of mounting has not been employed previously for any animal of such great weight.

From the character of the backbone and from the thick pads of cartilage between the bones of the loosely jointed legs it is inferred that dinosaurs of this type spent a considerable part of their times in streams and lakes. However, it is highly probable that they could and did wander over the land on occasion.

The bones in the back of this animal furnish a wonderful illustration of the way in which nature has sometimes attained a maximum of strength with a minimum of weight in that the arches are constructed on the T-iron principle of modern bridge building.

As the head was proportionally very small, with light jaws and spoon-shaped teeth in the front of the mouth only, it is thought that *Brontosaurus* fed on some very abundant and nutritious water plant that flourished in the subtropical climate of the time in which it lived, estimated at approximately a hundred million years ago. The clawed feet were presumably used in uprooting the plants, while the teeth were employed only for pulling them out of the water, and the food was drawn down the throat in large quantities without mastication. The final trituration of the food was carried out by the so-called "stomach stones," contained presumably in a sac, like the gizzard of modern birds. The quantity of food required to maintain these large bodies is calculated to have been at least a half ton each day.

The intelligence of these beasts must have been of a very low order, as it is known that the brain cavity was exceedingly small. An elephant has about nine pounds of brain matter to four tons of total weight, while *Brontosaurus* probably had less than one pound to forty tons. However, the mechanical functions of its body were controlled by the spinal nerve centers, the largest of which, located in the cavity of the backbone in the hip region, may have been many times larger than the brain.

Dinosaurs, to which group *Brontosaurus* belongs, are wholly extinct reptilian animals having no near relatives in the living world. Their kinship on one side is with the birds and on the other, rather less remotely, with the crocodiles and alligators. They were the dominant forms of life during Mesozoic time, and their remains are found in many diverse parts of the world, notably in western North America, Africa and certain parts of Europe. The range of size varied between that of a little fellow about a foot long to that of *Brontosaurus* and probably larger.

Besides these huge plant-feeding dinosaurs there were the carnivorous land forms which attained a length up to twenty feet or more. They progressed on their hind limbs and used their small short fore limbs for seizing and holding their prey. Their jaws were provided with numerous large sharp-edged teeth, usually serrated. Their size, their speed and their sharp claws and teeth made them perhaps the most powerful machines of destruction that nature has produced.

While the dinosaurs of this time were the largest forms of animal life yet there were many other kinds of beasts. Probably from the present-day standpoint the most interesting were the little warm-blooded mammals which were just beginning to get a foothold, as we know from the bones found in England and North America. In spite of the contrast in size between the two groups—the entire bodies of some of the mammals were no larger than a single tooth of a carnivorous dinosaur—these small forms persisted, while the gigantic dinosaurs vanished and gave rise to the later varied forms of mammals which spread over the entire globe.

In the seas were fish-lizards and other carnivorous marine reptiles whose slender elongated jaws were provided with continuous rows of sharp teeth. Their food consisted mainly of the ganoid fishes which reached their highest development in the Jurassic, of cuttlefishes and probably of sharks. There were very few bony fishes at that time. Crocodiles of the gavial type were quite abundant in the seas and rivers.

About a thousand species of insects were present, together with the first toothed birds, but the flying reptiles, for example, *Pteranodon*, dominated the air. This reptile had a known wing spread up to twenty-two feet. The jaws usually bore numerous long, slender, pointed teeth for holding prey.

The vegetation of those days was far different from to-day, although some of those early forms still exist. There were almost no flowering plants. The bulk of the flora consisted of cycads, rushes, tree ferns and conifers.